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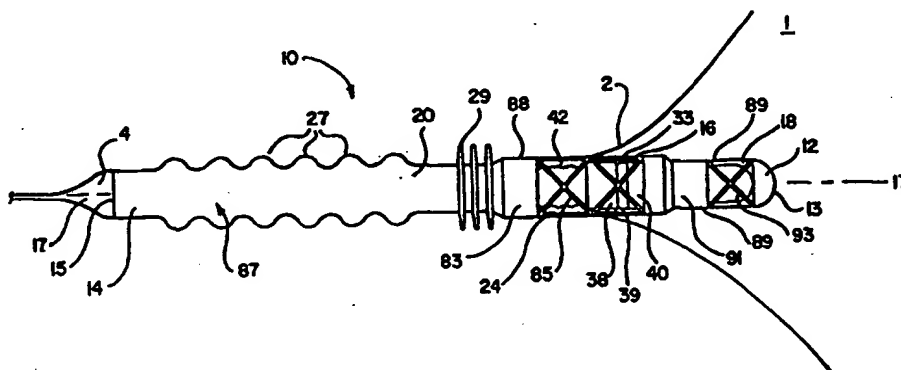


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(54) Title: **URETHRAL APPARATUS WITH HIGH FLOW VALVE AND METHODS OF USE THEREOF**



(57) Abstract

The present invention is an apparatus, and method for controlling urinary incontinence in an individual. The apparatus comprises a tubular device (10) for placement in the urethra of the individual. A proximal portion (12) of the device is adapted for placement in communication with the bladder of the individual, and a distal portion (15) of the tubular device is opposite from the proximal portion. A lumen (21) extends through the device from a distal opening (19) located in the distal portion to a proximal opening located in the proximal portion. The device includes an actuator (22) which is responsive to an actuation force or pressure applied thereto. A valve (42) is operated by the actuator which operates to open, and close the proximal opening. In one aspect, the valve is comprised of a flexible bellows which is movable between first and second positions to alternately open and close the proximal opening. According to a further aspect of the device, the actuator is damped so that its operation of the valve requires application of a sustained actuation force or pressure for a predetermined duration of time. In one embodiment, the actuation pressure results from fluid pressure within the bladder. In another embodiment, the actuation force results from application of a magnetic field.

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1 URETHRAL APPARATUS WITH HIGH FLOW VALVE
2 AND METHODS OF USE THEREOF
3

4 REFERENCE TO RELATED APPLICATIONS

5 The present application claims priority to U.S. provisional application Ser. No.
6 60/036,944, filed February 7, 1997, the entire disclosure of which is incorporated
7 herein by reference, and relates to U.S. application Ser. No. 08/914,487 entitled
8 "URETHRAL DEVICE WITH ANCHORING SYSTEM" filed August 19, 1997, and
9 U.S. application Attorney Docket No. 8886/8 entitled "URETHRAL APPARATUS
10 WITH POSITION INDICATOR AND METHODS OF USE THEREOF" filed on
11 even date herewith, the entire disclosures of which are incorporated by reference
12 herein.
13

14 FIELD OF THE INVENTION

15 The present invention relates generally to apparatuses for placement in the
16 urethra and methods of using such apparatuses, and more particularly to apparatuses
17 that can be positioned in the urethra for short-term or long-term use and that provide
18 functions such as valving for flow control.
19

20 BACKGROUND OF THE INVENTION

21 Urinary problems include urine retention, incontinence, and difficult urination.
22 Inability to evacuate retained urine may lead to damage of the epithelium and detrusor
23 muscles associated with the urethra and to an increased potential for bacterial invasion
24 and urinary tract infection. Incontinence, which is the inability to retain urine because
25 of the paralysis or relaxation of sphincter muscles or because of the contraction of
26 longitudinal muscular layers of the bladder, is not only a social problem but also one of
27 the leading causes of institutionalization of the elderly. Difficult urination or dysuria
28 can lead to problems similar to those of urine retention.

29 Devices have been developed and used in attempts to correct the problems of
30 urine flow. One conventional device is the indwelling Foley catheter. The Foley
31 catheter has an inflatable balloon attached at one end. The Foley catheter is positioned
32 in the urethra with the proximal end in the bladder. The inflatable balloon is used to

1 anchor the proximal end of the Foley catheter in the bladder. Urine enters the Foley
2 catheter through drainage holes which are located along the catheter shaft proximal of
3 the balloon. The distal end of the Foley catheter extends externally of the urethra and
4 is attached to a urine collection system. The need for an external urine collection
5 system makes the Foley catheter undesirable to many individuals. Furthermore,
6 because the balloon occupies a position in the bladder adjacent to the drainage
7 openings, it is difficult to evacuate the bladder completely, which may be
8 uncomfortable and may possibly lead to infections.

9 Another approach to address problems of urine control is intermittent
10 self-catheterization. According to this conventional approach, the patient inserts a
11 urinary drainage catheter to evacuate the bladder on a regular basis as needed. This
12 procedure is time-consuming and can lead to infection. Further, it can also lead to a
13 real or perceived lower quality of life. If done in public restrooms, self-catheterization
14 can be embarrassing and can lead to an increased risk of infection.

15 Another approach that has been taken to address urinary control problems is to
16 implant collagen and other materials alongside the urethra in an attempt to narrow the
17 urethral passageway. These materials have been known to migrate and lose their
18 effectiveness. Still other approaches involve surgeries, such as bladder neck
19 suspensions, sling operations, and implanted artificial urinary sphincters. Still other
20 approaches include occlusive devices that must be removed to void, while other
21 devices are valved devices.

22 Valved intraurethral devices have been developed for use by individuals who
23 have difficulties controlling urine flow. There are several factors that may have limited
24 more widespread usage of valved intraurethral devices. One factor is that the parts of
25 an intraurethral device which are in the flow path of the urine should be able to
26 withstand exposure to the urine. Over time, components which are exposed to urine
27 may become encrusted with solids from the urine. Another factor that may have
28 limited more widespread use of valved intraurethral devices has been the inability of
29 such devices to void the bladder completely and possess sufficient urine flow rates.

30 Accordingly, there is a need for an indwelling urethral device that can be used
31 by individuals to effect the voluntary control of urine.

1

2 SUMMARY OF THE INVENTION

3 To address the above concerns, the present invention provides an apparatus
4 and method for controlling urinary incontinence in an individual. The apparatus
5 comprises a tubular device for placement in the urethra of the individual. A proximal
6 portion of the device is adapted for placement in communication with the bladder of
7 the individual and a distal portion of the tubular device is opposite from the proximal
8 portion. A lumen extends through the device from a distal opening located in the distal
9 portion to a proximal opening located in the proximal portion. The device includes an
10 actuator which is responsive to an actuation force or pressure applied thereto. A valve
11 is operated by the actuator and operates to open and close the proximal opening. In
12 one aspect, the valve is comprised of a flexible bellows which is movable between first
13 and second positions to alternately open and close the proximal opening. According to
14 a further aspect of the device, the actuator is damped so that its operation of the valve
15 requires application of a sustained actuation force or pressure for a predetermined
16 duration of time. In one embodiment, the actuation pressure results from fluid
17 pressure within the bladder. In another embodiment, the actuation force results from
18 application of a magnetic field.

19

20 BRIEF DESCRIPTION OF THE DRAWINGS

21 Figure 1 is an expanded elevational view of a present embodiment of an
22 indwelling urethral device positioned within the bladder and urethra.

23 Figure 2 shows a partial sectional view of the embodiment of Figure 1.

24 Figure 3 is an expanded elevational view of the urethral device of Figure 1
25 positioned within the bladder and urethra shown in another stage of operation.

26 Figure 4a is an expanded distal end view of the actuator rod of Figure 2.

27 Figure 4b is an expanded side view of the actuator rod of Figure 2.

28 Figure 4c is a expanded proximal end view of the actuator rod of Figure 2.

29 Figure 5 is an expanded elevational view of another alternate embodiment of an
30 indwelling urethral device.

31 Figure 6 shows an expanded elevational view of another embodiment of an

1 indwelling urethral device positioned within the bladder and extending into the bladder
2 neck and urethra.

3 Figure 7 shows a partial sectional view of the urethral device of Figure 6.

4 Figure 8 shows a further expanded view of the proximal portion of the urethral
5 device of Figures 6 and 7.

6 Figure 9 shows an expanded partial sectional view of the urethral device of
7 Figures 6, 7, and 8 and an external magnet causing the urethral device to be in
8 another stage of operation.

9 Figure 10 shows a side view of a third embodiment of an indwelling urethral
10 device.

11 Figure 11 is a sectional view of the proximal portion of the embodiment of
12 Figure 10.

13 Figure 12 is a sectional view of the proximal portion of a fourth embodiment of
14 an indwelling urethral device.

15

16 DETAILED DESCRIPTION OF THE 17 PRESENTLY PREFERRED EMBODIMENTS

18 I. FIRST EMBODIMENT

19 The first embodiment includes a urethral device and associated method of use
20 that provide for the voluntary control of urine removal from the bladder of an
21 individual who suffers from urinary incontinence or other urine-control problems. The
22 individual may be either a male or female human, or alternatively, embodiments of the
23 device may be used in other mammals or even other non-mammal animals with suitable
24 changes in dimensions.

25 The urethral device of the first embodiment is hydraulically activated. The
26 device includes a pressure-sensitive actuator which is operated by voluntary application
27 of pressure to the bladder region. The pressure can be either externally applied (e.g.
28 pressing the abdomen in the region of the bladder with the fingers) or internally applied
29 (e.g. contracting the muscles in the region of the bladder as one would do during
30 normal urination). In a preferred embodiment, the actuator requires the sustained
31 application of pressure to the region of the bladder for a suitably long duration of time
32 to open a valve to discharge urine from the bladder through the device. This provides

1 for the damping of pressure impulses which might occur due to laughing, coughing,
2 exercising, and so on.

3 Further in a preferred embodiment, the actuating components are located outside the
4 flow path through the device by which urine is evacuated from the bladder. This
5 feature enables the dimensions of the flow path to be maximized to provide the
6 greatest flow rate and to facilitate complete voiding of the bladder.

7 Figures 1-5 show a first embodiment of an indwelling urethral device 10. In
8 Figure 1, the urethral device 10 is shown positioned partially within a bladder 1 of an
9 individual. The urethral device 10 extends distally into a bladder neck 2 and urethra 4
10 of the individual. The urethral device 10 has a body 20 with a proximal portion 12
11 terminating at a proximal end 13 and with a distal portion 14 terminating at a distal end
12 15. The body 20 has a wall 22 with an exterior surface 24 and has a generally tubular
13 shape around an axis 17. The cross-sectional shape of the body 20 may be generally
14 round or may be flattened to conform to the anatomical shape of the urethra of the
15 individual in whom the device is positioned.

16 The body 20 includes a main portion 87, a first casing 88, and a second (or
17 proximal) casing 89. The second casing 89 forms part of the proximal portion 12 of
18 the body 20 and extends distally to the first casing 88. The main portion 87 is formed
19 of a tubular member and comprises all or part of the distal portion 14 of the body 20.
20 The main portion 87 extends from the distal end 15 proximally to the distal end of the
21 first casing 88. The proximal end of the main portion 87 joins the distal end of the first
22 casing 88. The proximal end of the first casing 88 joins the distal end of the second
23 casing 89.

24 The main portion 87 includes a distal opening 19 which communicates with a
25 lumen 21 which extends from the distal opening 19 through the main portion 87. The
26 distal opening 19 may be provided with a recess 23 or other coupling arrangement 92
27 which can be used with other equipment in order to position and remove the urethral
28 device 10. The exterior surface of the main portion 87 may include anchors 27 or
29 other means for securing the urethral device 10 in the urethra once it has been
30 positioned. The anchors 27 may also facilitate positioning the urethral device in the
31 urethra. One or more sealing rings 29 may also be located on the exterior surface of

1 the main portion 87. The sealing rings 29 may be located along a proximal part of the
2 main portion 87 adjacent to the first casing 88. The sealing rings 29 are used to form a
3 fluid barrier between the urethral device 10 and the urethra 4 to limit or reduce leakage
4 of urine around the outside of the urethral device.

5 In one embodiment the main portion 87 of the device 10 is produced using a
6 composite construction of a base tube and cast external features. A base tube is
7 constructed as a braid reinforced silicone tube using a stainless steel wire braid and
8 Shore A 60 durometer silicone compound as the tube polymer (tubing produced by
9 New England Electric Wire Corp. Lisbon, NH). The internal diameter of the base tube
10 is 0.160 inches using a braid core diameter of 0.180 inches. The external diameter of
11 the base tube is 0.210 inches.

12 The urethral apparatus 10 has an overall length such that it resides entirely
13 within the urinary tract of the patient, preferably primarily within the urethra, except to
14 the extent to which the proximal end 13 extends partially or completely into either the
15 bladder or the bladder neck. The distal end 15 of the device 10 does not extend
16 outside the urethra after it is positioned. In present embodiments, the device is less
17 than 10 cm in length in versions for adult-sized male users and 5 cm in length for adult-
18 sized female users, but more preferably less than 5 cm in length for female users.

19 The device 10 may be sized from about 10 French to 34 French to
20 accommodate the large range of urethral sizes from infants to adults. The exterior
21 surface of the device is constructed of molded silicone or alternatively of latex.
22 Alternative materials include molded polyurethane, polyethylene, polycarbonate, or
23 other biocompatible materials.

24 The first casing 88 includes one or more drainage ports 16 formed by one or
25 more openings that extend through the wall 83 from which the first casing 88 is made.
26 The drainage ports 16 allow fluid to pass from outside the first casing 88 to the interior
27 thereof. In a present embodiment, the drainage ports 16 are formed by relatively large
28 spaces formed between skeletal structural parts or struts 85 which form part of the
29 wall 83 of the first casing 88. This construction provides a relatively large passageway
30 for fluid flow across the casing wall boundary thereby posing only limited resistance to
31 flow.

1 The second casing 89 includes one or more actuator ports 18. Like the
2 drainage ports 16 in the first casing 88, the actuator ports 18 may be formed by
3 openings that extend through the wall 91 from which the second casing 89 is formed.
4 The actuator ports 18 allow fluid (or at least fluid pressure) to pass from outside the
5 second casing 89 to the interior thereof. Like the drainage ports 16, the actuator ports
6 18 may be formed by relatively large spaces formed between skeletal structural parts or
7 struts 93 which form part of the wall 91 of the second casing 89. This construction
8 provides a relatively large passageway for fluid flow across the wall boundary of the
9 second casing 89 thereby posing only limited resistance to flow.

10 Referring to Figures 1 and 2, located inside of the first casing 88 is a valve
11 which in a preferred embodiment is a bellows valve 42. The bellows valve 42 is
12 formed of a flexible, resilient, and fluid-impervious tubular material. The bellows valve
13 42 defines a urine-flow passageway 43 through the interior thereof. A distal end of the
14 bellows valve 42 is coupled to a mounting flange 80. The mounting flange 80 is
15 coupled to a proximal end of the tubing 84 which forms the main portion 87. The
16 tubing 84 in turn is coupled to a distal end of the interior wall of the first casing 88.
17 The connections between the distal end of the bellows valve 42, the mounting flange
18 80, the tubing 84, and the first casing 88 may be made by any suitable means of
19 connection, such as adhesives 94, ultrasonic bonding, welding, multi-part epoxies,
20 friction fitting, shrink fitting, or other connection methods.

21 At least one marker used for device location using ultrasound or x-ray can be
22 located along the length of the urethral device 10. In a present embodiment, a marker
23 90 is located between the mounting flange 80 and the tubing 84.

24 Located at a proximal end of the bellows valve 42 is an ultrasoft annular ring
25 38. The annular ring 38 has a soft flexible proximal rim or lip 33. The annular ring 38
26 defines a proximal opening 39 (shown in Figure 3) that leads to the urine-flow
27 passageway 43 in the bellows valve 42. The proximal opening 39 defined by the
28 annular ring 38 provides the entrance into the urethral device 10 by which urine can be
29 eliminated from the bladder 1.

30 Coupled to an inside wall of the ultrasoft ring 38 is a distal end of an actuator
31 rod 72. As shown in Figures 4a, 4b, and 4c, the actuator rod 72 is formed of a central

1 shaft portion 73 having a distal end coupled to a distal ring 78 by means of radial struts
2 75. The actuator rod 72 also includes a disk 77 coupled to a proximal end of the
3 central shaft portion 73. The actuator rod 72 may be formed of a one piece metallic or
4 plastic material.

5 Located inside the first casing 88 directly adjacent proximally from the
6 proximal end of the ultrasoft ring 38 is a generally cylindrically shaped plug 41. A
7 proximal end of the plug 41 is fixed to the inside wall of the first casing 88. The
8 central shaft portion 73 of the actuator rod 72 extends through an axial bore 47 located
9 through the plug 41. The exterior distal shape of the plug 41 is slightly tapered so that
10 an outer diameter of the plug 41 is less at its distal end than at its proximal end. The
11 exterior of the plug 41 may be tapered along its entire length (e.g., frusto-conical) or
12 alternatively, the taper may begin at an intermediate location along the length of the
13 plug.

14 The tapered, distally facing exterior surface of the plug 41 forms an angular
15 flange 40. The angular flange 40 forms a proximal valve seat against which the
16 ultrasoft ring 38 moves to form a seal to prevent fluid from entering into the proximal
17 opening 39 defined by the ultrasoft ring 38.

18 The bellows valve 42, and in particular the proximal end of the bellows valve
19 42, is displaceable along the axis 17. The bellows valve 42 may be formed of a spring
20 44 encapsulated by a very thin plastic sleeve or layer 45. The layer 45 may be
21 composed of a suitably strong, yet flexible material, such as PTFE. The encapsulated
22 spring 44 provides the bellows valve 42 with a shape-memory property. Thus, the
23 bellows valve 42 can be deformed in length (i.e. shortened or stretched) by application
24 of a compressive or tensile force, and the bellows valve 42 will resume its original size
25 upon removal of the applied force. In alternative embodiments, the bellows spring 44
26 can be omitted and instead the bellows material can be selected to provide the desired
27 shape-memory property.

28 Referring to Figure 2, inside the second casing 89 are a sealed proximal fluid
29 reservoir 60 and a sealed distal fluid reservoir 62. The proximal and distal fluid
30 reservoirs 60 and 62 are filled with a fluid 58. The proximal and distal fluid reservoirs
31 60 and 62 are separated from each other by a barrier plate 64. Located in the barrier

1 plate 64 is a fluid passageway 66. The fluid passageway 66 provides a restricted fluid
2 path between the proximal and distal reservoirs 60 and 62 by which the fluid 58 can
3 pass between the reservoirs.

4 Part or all of the wall which forms the proximal reservoir 60 is formed of a
5 flexible material which forms a proximal membrane 52. The proximal membrane 52 is
6 located inside the second (proximal) casing 89 adjacent to the actuator ports 18. Thus,
7 the proximal membrane 52 is exposed to fluid or fluid pressure from the area outside
8 of the second casing 89.

9 Located inside the proximal reservoir 60 is a proximal spring 56. The proximal
10 spring 56 is located axially inside the proximal reservoir 60. The proximal spring 56
11 has a preset load of approximately .7 gram. A distal end of the proximal spring 56
12 bears against the proximal side 67 of the barrier plate 64. Specifically, the distal end of
13 the proximal spring 56 is seated in a recess 63 in the proximal side 67 of the barrier
14 plate 64. (The proximal spring is included in this embodiment although in alternative
15 embodiments, the proximal spring may be omitted). A proximal opening 69 located at
16 the bottom of the recess 63 leads to the fluid passageway 66 that communicates
17 between the proximal and distal reservoirs 60 and 62.

18 A proximal end of the proximal spring 56 is coupled to a domed retainer 54.
19 The domed retainer 54 is formed of a rigid material. The domed retainer 54 is located
20 in a proximal end of the proximal reservoir 60. When the walls of the proximal
21 reservoir 60 are formed of a flexible material, the exterior shape of the proximal end of
22 the proximal reservoir 60 is defined by the shape of the domed retainer 54. The
23 proximal end of the proximal reservoir 60 is adjacent to, but preferably spaced from,
24 an inside wall of the proximal end 13 of the device defined by the proximal end of the
25 second casing 89. The proximal end of the second casing 89 may have a shape that
26 conforms generally to the shape of the domed retainer 54.

27 Part or all of the wall which forms the distal reservoir 62 is formed of a flexible
28 material which forms a distal membrane 68. The distal membrane 68 is located inside
29 the second casing 89 at a distal end thereof adjacent to the disk 77 of the actuator rod
30 72. When the distal membrane 68 is in position adjacent to the disk 77, it may be in
31 direct contact with the disk 77, however, preferably, the distal membrane 68 is spaced

1 from the disk 77 by a small distance. In one embodiment, the distal membrane 68 is
2 formed with a concave shape so that a central, on-axis portion of the distal membrane
3 68 is spaced away from the disk 77, as shown in Figure 2.

4
5 Operation. The urethral device 10 is positioned in the urethra 4. Positioning
6 may be accomplished using conventional techniques. Alternatively, the urethral device
7 may be positioned in the urethra using the techniques and/or equipment disclosed in
8 the referenced copending application entitled "URETHRAL APPARATUS WITH
9 POSITION INDICATOR AND METHODS OF USE THEREOF."

10 After the urethral device 10 is successfully positioned in the urethra 4 of the
11 individual, it is used to control urine flow from the bladder 1. When the urethral
12 device 10 is in place and the pressure of the urine in the bladder is below a
13 predetermined threshold for a predetermined period of time, urine is prevented from
14 entering into the urethral device 10 by the seal formed by the annular ring 38 against
15 the angular flange 40. Under these conditions, the proximal spring 56 biases the
16 domed retainer 54 in a proximal direction away from the barrier wall 64 causing the
17 domed retainer 54 to be moved to a proximal position, as shown in Figure 2. When
18 the domed retainer 54 is in its proximal position, the volume of the proximal reservoir
19 60 is maximized, and likewise the volume of fluid 58 filling the proximal reservoir 60 is
20 maximized. When the volume of fluid in the proximal reservoir 60 is maximized, the
21 amount of fluid 58 in the distal reservoir 62 is correspondingly minimized. When the
22 fluid 58 in the distal reservoir 62 is minimized, it is insufficient to cause the distal
23 membrane 68 to push the disk 77 of the actuator rod 72 in a distal direction. Instead,
24 the distal membrane 68 is drawn to a proximal position, which may be everted as
25 shown in Figure 2.

26 When the distal membrane 68 is in its proximal position, the distal ring 78
27 which is fixed to the actuator rod 72 is pushed to its proximal position, as shown in
28 Figures 1 and 2, by the relatively low biasing force of the bellows valve 42. When the
29 actuator rod 72 is in its proximal position, the proximal lip 33 of the ultrasoft annular
30 ring 38, which is located at the proximal end of the bellows valve 42, is caused to bear
31 against the angular flange 40 with a predetermined axial force. When the proximal lip

1 33 is located at the angular flange 40, a compressive normal force is applied to the
2 proximal lip 33 of the annular ring 38 by the pressure of any urine in the bladder. This
3 compressive force of the urine on the proximal lip 33, combined with the proximally
4 directly axial force of the bellows valve 42, causes a fluid-tight seal to be formed
5 between the annular ring 38 and the angular flange 40.

6 When the urethral device is in position, the fluid seal provided by the annular
7 ring 38 and the angular flange 40 is maintained even if the fluid pressure in the bladder
8 rises sharply for brief, transient periods of time, such as when the individual is
9 coughing, sneezing, laughing, exercising, and so on. Because the passageway 66
10 between the proximal and distal reservoirs 60 and 62 is relatively narrow, short
11 transient peaks of pressure in the bladder do not cause appreciable fluid to flow from
12 the proximal reservoir 60 to the distal reservoir 62, therefore the seal between the
13 annular ring 38 and the angular flange 40 remains intact.

14 Activation of the urethral device 10 to permit urine flow from the bladder
15 occurs when the proximal membrane 52 and the domed retainer 54 are displaced
16 distally along the axis 17. As mentioned above, the proximal spring 56 has a preset
17 load of approximately .7 gram. This biasing force resists distal movement of the
18 domed retainer 54 until bladder pressure reaches a predetermined level. The build up
19 of pressure in the bladder to the level necessary to cause distal movement of the domed
20 retainer 54 and proximal spring 56 may be brought about by voluntary muscular
21 contraction. This build up may be augmented by the manual application of pressure
22 from external of the body in the region adjacent to the bladder. To initiate movement
23 of the domed retainer 54, the application of pressure is required to be maintained for a
24 sustained duration of time which assures that the application of pressure is voluntary
25 and not due to transient occurrences, such as coughing, laughing, etc.

26 When the bladder pressure reaches the preset magnitude for the sustained
27 period of time, the domed retainer 54 begins to move distally. This movement is
28 caused by the pressure build-up in the bladder which is transmitted to the outside
29 surface (i.e. the proximal membrane 52) of the proximal reservoir 60 via the actuation
30 ports 18. This movement of the domed retainer 54 results in fluid 58 being displaced
31 from the proximal reservoir 60 to the distal reservoir 62 through the passageway 66

1 located through the barrier plate 64. As fluid 58 enters the distal reservoir 62, the
2 distal membrane 68 is displaced distally along the axis 17 and pushes against the
3 proximal surface 74 of the disk 77 of the actuator rod 72. In an embodiment in which
4 the distal membrane 68 has a concave shape when the fluid 58 in the distal reservoir 62
5 is minimized, the distal membrane 68 may evert to form a convex, or bowed out, shape
6 as the fluid 58 fills into the distal reservoir 62. In one embodiment, the actuator rod 72
7 does not move immediately when fluid 58 begins to be displaced from the proximal
8 reservoir 60 through the passageway 66 to the distal reservoir 62. Instead, the
9 actuator rod 72 begins moving distally when sufficient pressure is applied against the
10 proximal surface 74 of the disk 77 of the actuator rod 72 by the distal membrane 68.

11 As fluid 58 continues to fill the distal reservoir 62, the distal membrane 68
12 continues to move distally, bearing against the proximal surface 74 of the disk 77 of
13 the actuator rod 72 and causing the actuator rod 72 to move distally along the axis 17.
14 Because the distal ring 78 of the actuator rod 72 is fixed to the annular ring 38, distal
15 axial movement of the actuator rod 72 causes the annular ring 38 to likewise move
16 distally. Distal movement of the annular ring 38 is opposed by the relatively low,
17 proximally directed biasing force of the bellows valve 42 which is overcome by the
18 greater, distally directed force. Thus, the bellows valve 42 is caused to be compressed.
19 This distal movement of the annular ring 38 separates the annular ring 38 and the
20 angular flange 40, as shown in Figure 3. This permits urine to flow into the first casing
21 88 through the drainage ports 16, through the proximal opening 39 in the annular ring
22 38, and into the passageway 43 of the bellows valve 42. Urine flows past the struts 75
23 of the distal ring 78 of the actuator rod 72 into the main body lumen 21 in the main
24 body portion 87. The urine then flows out through the opening 19 at the distal end 15
25 of the device 10 into the urethra 4, and out from the body of the individual.

26 When the bladder is substantially empty, the pressure in the bladder is reduced,
27 and urine flow ceases. The reduction of pressure in the bladder may be accomplished
28 by voluntary cessation of the muscular contractions which caused the pressure, the
29 removal of external application of pressure to the bladder region, by the emptying of
30 the bladder, or a combination of these factors. This reduced pressure in the bladder is
31 insufficient to overcome the biasing of the proximal spring 54 which moves the domed

1 retainer 54 back to its proximal position. This draws the fluid 58 from the distal
2 reservoir 62 back to the proximal reservoir 60. Without the opposing force from the
3 distal membrane 68, transmitted through the actuator rod 72, the compressed bellows
4 valve 42 relaxes back to its extended condition, thereby sealing the annular ring 38 to
5 the angular flange 40. At the same time, the proximal movement of the annular ring 38
6 causes the attached actuator rod 72 to move proximally. The urethral device is ready
7 to prevent urine flow from the bladder again.

8 The operation of the urethral device 10 to permit urine flow from the bladder is
9 controlled by the variables of time and pressure within the bladder 1. The size of the
10 passageway 66 restricts the flow rate of the fluid 58 between the proximal reservoir 60
11 and the distal reservoir 62. This restriction provides a time delay between reaching the
12 preset pressure level (at which initiation of movement of fluid from the proximal to the
13 distal reservoirs begins) and the initiation of the movement of the actuator rod 72. In
14 this manner, the urethral device 10 damps any involuntary pressure impulses which
15 might occur which might open the device. A sustained pressure over a relatively
16 substantial duration of time is required to cause a sufficient quantity of fluid 58 to
17 move from the proximal reservoir 60 to distal reservoir 62 and, thus, to move the
18 actuator rod 72 distally. This sequence of functions provides for predictable,
19 controlled activation, damping, and over-pressure protection for the bladder and
20 kidneys.

21

22 Materials and construction: The tubing 84 of the main body portion 87 of the
23 urethral device is formed of a silicone tubing reinforced with a stainless steel
24 wire-braid. The tubing has an outside diameter of approximately 5.3 mm (.210 inches)
25 and an inside diameter of approximately 4.1 mm (.160 inches). The length of the
26 tubing is selected and/or varied to conform to the anatomical features of the individual
27 in whom the device is positioned. For example, the overall length can vary from less
28 than 10 cm for male users to less than 5 cm for female users, although lengths greater
29 than these may be provided.

30 In one embodiment, the silicone material of the tubing is a blend of NuSil MED
31 4115 and MED 4116 in a 1:1 mix ratio to achieve a Shore A 60 durometer hardness.

1 The stainless steel wire braid is 316L wire braided at 14 picks per inch, 2 ends per
2 carrier, and 16 carriers using a braid core diameter of approximately 4.6 mm (.180
3 inches). The exterior features, such as the anchors 27 used to anchor the device in the
4 urethra and the sealing rings 29, are formed by casting silicone rubber features onto the
5 tubing. These features are formed from NuSil compound number MED4-4220, parts
6 A and B blended to yield at Shore A 30 durometer feature. In one embodiment the
7 anchoring and sealing features are formed in accordance with the above-referenced
8 U.S. patent application Ser. No. 08/914,487.

9 The first casing 88 is a tubular section formed from a high durometer urethane
10 or semi-rigid medical grade PVC. The inside diameter is approximately 6.1 mm (.240
11 inches), and the outside diameter is approximately 6.6 mm (.260 inches). The first
12 casing encloses the bellows valve 42 and connects the distal end of the second casing
13 89 to the body tubing 84 while keeping these components coaxially aligned. The first
14 casing maintains its cylindrical cross-section during bending.

15 The second casing 89 is a closed end, tubular section formed from a high
16 durometer urethane or semi-rigid medical grade PVC. The inside diameter is
17 approximately 5.1 mm (.200 inches), and the outside diameter is approximately 5.6 mm
18 (.220 inches). The second casing protects the proximal and distal membranes from
19 damage and maintains a cylindrical cross-section during bending.

20 In one embodiment, the annular ring 38 is constructed from Shore A 30
21 durometer medical grade silicone rubber (i.e. NuSil MED4-4220). The annular ring 38
22 has an overall length of approximately .150 inches. The annular ring 38 includes a soft
23 flexible lip 33 which seals to the angular flange 40 to prevent urine flow into the
24 device. The proximal lip 33 of the annular ring 38 is formed to be approximately .010
25 inches thick by approximately .100 inches long. In an alternative embodiment, the
26 annular ring may be tapered.

27 The plug 41 is composed of Teflon TFE and Acetal (Delrin AF) blend. The
28 present geometry of the plug is tubular with a 15-degree distal taper to form the
29 angular flange 40. The taper allows for a slight stretching of the annular ring 38 as the
30 ring 38 and flange 40 are pushed together by the bellows valve 42. The plug 41 is
31 tubular to allow the actuator rod 72 to pass through the bore 47 located therein. The

1 proximal portion of the plug 41 is cylindrical to interface with the second casing 89.
2 The outer diameter of the plug 41 is approximately 5.1 mm (.20 inches), and the
3 diameter of the bore 47 is approximately 1.7 mm (.065 inches).

4 The flexible bellows valve 42 is constructed from a compression spring 44
5 within a layer formed of a thin polypropylene sleeve 45. In one embodiment, the
6 bellows spring 44 is formed from 302 stainless steel wire. The spring constant of the
7 bellows spring 44 is approximately 4.5 N/m (.026 lbf/in) using an approximately .15
8 mm (.006 inches) wire wound with 6 active coils and 2 dead coils. The sleeve or layer
9 45 is formed using a polypropylene film approximately .013 mm (.0005 inches) thick.
10 The layer or layer 45 is formed using a Teflon film approximately .001 inches thick.

11 In alternative embodiments, the bellows valve can take other forms. For
12 example, instead of a bellows-like construction, the bellows valve can be formed of
13 two or more telescoping rigid sections. Like the bellows valve, the overall length of
14 the telescoping sections could be shortened to expose the opening to the device
15 passageway by applying a compressive axial force, as in the bellows-valve
16 embodiment. The telescoping sections would be provided with a shape-memory
17 property such that they would assume their original overall length after the
18 compressive axial force was removed. As in the first embodiment, the shape-memory
19 property could be provided by a spring located inside the telescoping sections. In still
20 further embodiments, the valve can take forms other than a bellows or telescopic
21 construction. For example, the valve may be gate valve or a bulb valve, or other type
22 of valve. In such alternative embodiments of the valve, it is preferable that the
23 actuation threshold of the valve be relatively low so that it can be operated with forces
24 of the magnitudes indicated above.

25 In a present embodiment, part or all of the walls which form the proximal and
26 distal fluid reservoirs 60 and 62, including the proximal and distal membranes 52 and
27 68, are formed of a single bag of extruded plastic material. In this embodiment, the
28 bag is formed by a slow extrusion process whereby a thin film is stretched over a
29 Teflon mandrel. The film is a polypropylene film, approximately .015 mm
30 (.0006 inches) thick from Hytech Film Inc., Kaukauna, WI. After the extrusion
31 process is completed, the membrane wall is approximately .0075 mm (.0003 inches)

1 thick. After filling with fluid 58, the proximal end of the proximal membrane 52 is
2 sealed. The sealing is accomplished by tying the membrane bag shut and filling the tied
3 area with a thin, cyanoacrylate-family adhesive (e.g., Sicomet™ 77). In alternative
4 embodiments, the proximal and distal membranes may be formed of separate bags or
5 materials.

6 In a present embodiment, the domed retainer 54 is composed of a medical
7 grade polycarbonate or a high durometer urethane. This component acts on the
8 proximal membrane 52 to return the membrane to its original shape after the bladder
9 pressure has returned to its low pressure state (<10 cm of water pressure). The
10 diameter of the domed retainer is approximately 4.3 mm (.170 inches).

11 The proximal spring 56 may be composed of a compression spring formed from
12 302 stainless steel wire. Its spring constant is approximately 19.25 N/m (.11 lbf/in)
13 using approximately .15 mm (.006 inches) wire wound with 3 active coils and 2 dead
14 coils. The proximal spring 56 is installed within the reservoir 60 formed by the
15 proximal membrane 52. The proximal membrane is sealed so that the spring is
16 preloaded to approximately .73 grams of force. The geometry of the spring can be
17 varied to provide different spring constants that result in the domed retainer 54 moving
18 at different pressure thresholds.

19 As mentioned above, the proximal spring may be omitted in alternative
20 embodiments. Among some patient populations, it may not be necessary to provide
21 the biasing force of the proximal spring and the device may be restored to a closed
22 position using the biasing force of the bellows spring alone.

23 The fluid 58 performs the function of transferring the pressure acting on the
24 surface of the proximal membrane 52 to the surface of the distal membrane 68. The
25 fluid 58 is essentially incompressible. The fluid moves through the fluid passageway
26 66 in the barrier wall 64 to fill the distal reservoir 62. The diameter, length, entrance
27 angle and roughness of the fluid passageway 66 control the rate of fluid flow. The
28 viscosity of the fluid 58 also affects the flow rate. In a present embodiment, clean
29 water is used as the fluid 58. In alternate embodiments, the fluid may be composed of
30 bio-compatible oils, for example, with viscosities higher than water, to achieve a
31 reduction in flow rate through the passageway 66.

1 The barrier plate 64 is made from 304 stainless steel and the passageway 66 has
2 a diameter of approximately .3 mm (.013 inches). This diameter is sized to provide the
3 desired amount of fluid volume through the orifice over a time period of
4 approximately 3 seconds. The range of orifice sizes can vary greatly to allow for
5 various time damping effects to the distal portions of the device. In one embodiment,
6 the barrier plate 64 is formed of an injection-molded plastic part with the passageway
7 hole 66 formed using a secondary operation to ensure an accurate hole diameter size
8 and burr-free construction. The fluid passageway geometry and dimensions, such as
9 the angle of entry into the passageway 66, the diameter, and the length, and any
10 manufacturing defects such as burrs, affect the performance characteristics of the
11 passageway. These aspects can be modified to tune the passageway performance to
12 desired specifications. The outside perimeter surface of the barrier plate 64 is relieved
13 to facilitate forming a seal with the extruded bag used to form the proximal and distal
14 reservoirs.

15 In an alternative embodiment, a two-piece construction may be used for the
16 barrier plate 64. In a two-piece construction, a relatively hard material, whose
17 dimensions can be precisely controlled, is used to form the fluid passageway 66, and
18 another, softer material is used for the rest of the barrier plate 64. For example, a
19 stainless steel tube can be used to provide the fluid passageway 66, and an outer ring
20 of silicone rubber can be cast over the stainless steel tube to form the rest of the barrier
21 plate 64. A two-piece embodiment of the barrier plate 64 provides the advantage that
22 the outside portion can be formed of a more flexible material to facilitate placement
23 and use of the device.

24 The actuator rod 72 and the proximal disk 77 are formed from a 304 stainless
25 steel wire and disk, respectively. The diameter of the wire is approximately .51 mm
26 (.020 inches) and the thickness of the disk is approximately .51 mm (.020 inches).

27 The mounting flange 80 is formed of a short tubular section of medical grade
28 polycarbonate. In one embodiment, the mounting flange has an outside diameter of
29 approximately 3.9 mm (.154 inches) and an inside diameter of approximately 3.4 mm
30 (.134 inches).

31 The marker 90 is formed from a relatively radiopaque or acoustically opaque

1 material, such as a metal wire coil. In one embodiment the marker 90 is formed using
2 304 stainless steel wire having a diameter of approximately .13 mm (.005 inches) at a
3 pitch of approximately .18 mm (.007 inches).

4 The coupling insert 92 at the distal end of the device is formed of a short
5 tubular section with an internal relief along its axis. The coupling insert 92 is made of
6 medical grade polycarbonate. The present dimensions of the coupling insert 92 are
7 approximately 3.9 mm (.154 inches) outside diameter and approximately 3.6 mm
8 (.140 inches) inside diameter. The coupling insert 92 may be used in cooperation with
9 an insertion tool as disclosed in the above referenced copending U.S. patent
10 application Attorney Docket No. 8886/8 entitled "URETHRAL APPARATUS WITH
11 POSITION INDICATOR AND METHODS OF USE THEREOF" filed on even date
12 herewith.

13 For most bonding connections, a silicone-based adhesive, such as NuSil
14 MED-1011 (acetoxycure system) or NuSil LSR1-9879, are used with CF1-135 primer
15 to speed bonding. Medical grade, two-part epoxy such as Tra-Con P/N Tra-Bond
16 FDA-8 may be used also.

17
18 Advantages: The embodiments of the urethral device described above include
19 several advantages. One of the advantages is that the device is able to provide a fluid
20 seal with a relatively very low force, for example less than approximately 8 grams.
21 This enables the device to use very low pressures in the bladder to accomplish fluid
22 sealing. This feature is provided by one or more of the following factors: the ability of
23 annular ring 38 to stretch and conform to the shape of the angular flange 40, the
24 proximal profile of the annular ring 38 that is exposed to urine pressure, and the shape
25 and material characteristics of angular flange 40.

26 The ability of the annular ring 38 to stretch and conform is a function of both
27 its material and design. In one embodiment, the annular ring 38 is constructed of soft
28 silicone rubber that allows the annular ring to stretch easily. The wall thickness and
29 length of the annular ring 38 also influence its stiffness and/or its ability to stretch. The
30 wall thickness of the annular ring directly influences the stiffness of the ring, and the
31 length of ring inversely influences its stiffness. For example, an annular ring with a

1 wall thickness of .010 inches and a ring length of .100 inches requires a 2-gram axial
2 force to seal to an angular flange with a 15-degree taper. By appropriate modification
3 of the parameters of wall thickness and length, the ability of the annular ring to stretch,
4 and similarly the amount of force required to seal annular ring 38 to the angular flange
5 40, can be changed.

6 The lip seal arrangement is advantageous because it uses external pressure (in
7 this case urine pressure from the bladder) to assist in sealing the proximal lip 33 of the
8 annular ring 38 to the angular flange 40. The annular ring 38 is pressed to the angular
9 flange 40 by the urine pressure acting on the outer circumference of the proximal lip 33
10 of the annular ring 38.

11 In a present embodiment, the proximally facing, projected surface area of the
12 annular ring 38 is minimized. Since the outside surface of the annular ring 38 is
13 exposed to the fluid pressure within the bladder, the proximally facing projected
14 surface area of the proximal lip of the annular ring 38 experiences a distally directed
15 force generated by this bladder pressure. The magnitude of this distally directed force
16 is equal to the projected proximally facing area of the proximal lip times the urine
17 pressure. This distally directed force acts against the sealing force. For this reason the
18 proximally projected surface area of the annular ring is minimized.

19 The shape, cylindrical taper, and material characteristics of the angular flange
20 40 assist in minimizing the amount of sealing or axial force applied to the annular ring
21 38. The taper angle increases the normal force (or stretch force) component of the
22 axial force applied to the annular ring 40. This increase in normal force increases the
23 amount of friction between the annular ring 38 and the angular flange 40. The use of a
24 low-friction material for the angular flange 40 reduces the amount of friction between
25 the annular ring 38 and the angular flange 40. The reduction in friction force allows a
26 greater portion of the axial force to be used to stretch the annular ring 38.

27 Sealing an annular ring of the size disclosed above to an angular flange with a
28 15-degree taper requires approximately 1 to 2 grams of axial force to form a fluid-tight
29 seal at approximately 70 cm of water pressure. The ability to achieve a fluid-tight seal
30 at this magnitude of axial force is advantageous. It enables the pressure within the
31 bladder (transformed into an axial force) to open the annular ring to allow voiding the

1 bladder when a preset pressure level is attained. The seal is further capable of sealing
2 at pressures from approximately 0 cm to approximately 150 cm of H₂O which the
3 bladder can generate.

4 The length of the angular flange 40 also influences the performance of the
5 device. During initial distal movement of the annular ring 38, the angular flange 40 is
6 in the urine flow. The length of the angular flange 40 influences how much travel is
7 required by the annular ring 38 to clear the angular flange in order to achieve the
8 desired flow rate. A short angular flange 40 improves device performance with regard
9 to flow rate and magnitude of the annular ring displacement.

10 The ability of the bladder to produce sufficient pressure to initiate the drainage
11 of urine is limited to voluntary control by the individual due to normal micturition
12 urges, contractions, or external Crede methods. This pressure, which is externally
13 applied to the bladder, is transformed into a force that can be used to place the device
14 in an open condition by the separation of the annular ring 38 from the angular flange
15 40. For example, if the force on the domed retainer 54, which has a diameter of
16 approximately .180 inch, were to transform a bladder pressure of 50 cm of water
17 pressure completely to force, the device would generate 8.2 grams of force. Thus, 8.2
18 grams of force would be the maximum amount of force available to open the system.
19 This is a relatively small amount of force. With a device according to the first
20 embodiment, the device closes and, conversely, opens at forces of less than
21 approximately 10 grams and preferably at forces less than approximately 5 grams.

22 Another advantageous feature of the disclosed embodiment is the use of the
23 flexible bellows valve. The flexible bellows valve allows the proximal end of the
24 annular ring 38 to be displaceable along the axis 17 without incurring substantial
25 frictional losses inherent to other movable sealing methods (i.e., shaft seals).

26 Still another advantage of the disclosed embodiment is that the flow-control
27 actuator components (e.g., the fluid barrier plate and spring) are not in the exit flow
28 path of urine (via the drainage ports 16 in the first casing). This provides several
29 advantages. First, encrustation on the actuation components is reduced since these
30 critical components are not in the urine flow path. In addition, since these components
31 are outside the flow path, the size of the flow path can be increased, thereby permitting

1 a high flow rate of urine through the device.

2 The passageway 66 through the barrier plate 64 is constructed to have different
3 flow characteristics depending on whether fluid is flowing proximally or distally. The
4 proximal (or closing) movement of the annular ring 38 does not occur until the
5 actuator rod 72 is first allowed to move proximally. This proximal movement of the
6 actuator rod 72 is restricted and subjected to the time and pressure delay
7 characteristics provided by the proximal and distal reservoirs 60 and 62. This delay
8 permits full voiding of the bladder prior to resealing of the annular ring 38 with the
9 angular flange 40 to close the entrance to the fluid-flow passageway 43.

10 Another advantage of the disclosed device is that it is insensitive to relatively
11 short high pressure conditions in the bladder. Activities such as coughing, sneezing,
12 exercise, and laughing can cause peak pressures as great as 150 cm of H₂O. However,
13 these peak pressures only last for about one second. Because the annular ring cannot
14 move away from the angular flange until a sufficient amount of fluid moves through
15 the fluid passageway 66 from the proximal reservoir 60 to the distal reservoir 62, the
16 device will not inadvertently open due to short pressure impulses within the bladder.

17 Another advantage of the present embodiment is that it provides for protection
18 against over-pressurization of the bladder. As explained above, in order to operate the
19 device to allow urine flow, it is required to apply a sustained pressure of a predefined
20 magnitude for a predefined duration of time to the exterior of the distal membrane 68.
21 This sustained pressure is normally above the level which is comfortable for the
22 individual in whom the device is positioned, and therefore it is unlikely that the bladder
23 would become full and reach this pressure level without the individual becoming aware
24 of it. In the event the individual is unconscious or otherwise unable to operate the
25 device to void the bladder, a high pressure in the bladder due to the bladder being full
26 would be sustained for a sufficiently long duration of time to cause the device to open
27 to allow urine to flow. This fail-safe feature reduces the risk that the pressure in the
28 bladder might rise to an unsafe level and also reduces the risk of damage to the bladder
29 or kidneys.

30

31

1 Alternative embodiment. Figure 5 shows an alternative embodiment of the
2 urethral device of Figure 1. In this alternative embodiment, the main portion 87A
3 includes seminal ports 97. These seminal ports provide a relatively unobstructed
4 pathway for seminal fluids to pass from the seminal ducts to the urethra 4. The
5 seminal ports 97 are formed by a stamping process that precisely locates and shapes
6 them. The size, shape, and position of the seminal ports 97 can be configured to the
7 anatomical requirements of the individual.

8 9 II. SECOND EMBODIMENT.

10 A second embodiment of an indwelling urethral device used to control urine
11 flow in an individual is shown in Figures 6-9. The second embodiment includes some
12 components which are similar to those in the first embodiment, and such similar
13 components are indicated by the same numerals incremented by "200." The second
14 embodiment differs from the first embodiment in that it uses a magnetic actuator
15 assembly instead of a hydraulically actuated assembly to control fluid access into the
16 internal fluid-flow passageway of the device. In the second embodiment of the urethral
17 device, a first magnet, which is located external of the body of the individual in whom
18 the device is positioned, is brought into proximity of the abdominal region of the
19 individual close to the indwelling device. The magnetic field of the first magnet is used
20 to rotate a second magnet located inside the indwelling intraurethral device. The
21 second magnet effects operation of the valve of the indwelling intraurethral device to
22 allow urine to flow through the device. The flow-control mechanism used in the
23 second embodiment requires very little force for activation and thus offers the
24 advantage that the sizes of the two cooperating magnets used to activate the device
25 can be relatively small. In addition, as in the first embodiment, the actuating
26 components are preferably located in a portion of the device outside the flow path of
27 the urine being discharged through the device.

28 Referring to Figure 6, an expanded elevation view of the second embodiment is
29 shown. A urethral device 210 is positioned within the bladder 201, the bladder neck
30 202, and urethra 204. The device 210 has a body 220 with a proximal portion 212
31 terminating at a proximal end 213 and with a distal portion 214 terminating at distal

1 end 215. The body 220 has a wall 222 with an external surface 224 and has a
2 generally tubular shape around an axis 217. The cross-sectional shape of the body 220
3 may be generally round or may be flattened to conform to the anatomical shape of
4 urethra 204.

5 The body 220 includes a main portion 287 and a first casing 288. The first
6 casing 288 has drainage ports 216. Located in the first casing 288 is a bellows valve
7 242, an ultrasoft annular ring 238, and a plug 241 having a distal portion which forms
8 an angular flange 240. Referring to Figures 7 and 8, the bellows valve 242 is
9 connected at its proximal end to the annular ring 238 and is attached at its distal end to
10 a mounting flange 280. The mounting flange 280 is connected to the first casing 288,
11 as in the first embodiment. The bellows valve 242 is deformable in length along the
12 axis 217. Movement of the proximal end of the bellows valve 242 displaces the
13 annular ring 238 along the axis 217. A fluid passageway 243 extends through the
14 annular ring 238 and communicates with a distal fluid passageway 221 that extends
15 through the main portion 287 to the distal opening 219 at the distal end 215 of the
16 urethral device 210. A coupling insert 292 is bonded to the tubing 284 of the main
17 portion 287 at the distal end 215 of the urethral device 210. The coupling insert 292
18 can be used in cooperation with an insertion tool. In addition, at least one marker 290
19 can be located along the device, for example, between the mounting flange 280 and the
20 first casing 288. All the above components may be similar or identical to those in the
21 first embodiment.

22 The body 220 also includes a second casing 289. Unlike the second casing 89
23 of the first embodiment, the second casing 289 in the second embodiment does not
24 include actuator ports. Instead, the second casing 289 of this second embodiment is
25 sealed so that the components located inside the casing 289 are not exposed to the
26 bladder environment.

27 Located inside the second casing 289 is a sealed proximal cavity 226. An
28 internal magnet 291 is located in the proximal cavity 226 and mounted for limited
29 rotation about the axis 217. To provide for this rotation, a proximal pin 262 is
30 connected to a proximal end of the magnet 291 and is received in a proximal journal
31 264 located in a proximal wall of the proximal cavity 226. A distal pin 266 is

1 connected to a distal end of the magnet 291 and is received in a distal journal 269
2 located in a distal wall of the proximal cavity 226. The distal pin 266 extends through
3 the distal wall of the proximal cavity 226 into a flange cavity 271. The distal end of
4 the distal pin 266 is connected at its distal end to a barrel cam 268 which is located in
5 the flange cavity 271.

6 A cam housing 270 is located in the flange cavity 271. A proximal end of the
7 central shaft portion 273 of an actuator rod 272 extends into the flange cavity 271
8 through an opening centrally located in a distal wall of the flange cavity 271. (Unlike
9 the actuator rod 72 in the first embodiment, the actuator rod 272 in the second
10 embodiment does not include a proximal disk.) The central shaft portion 273 of the
11 actuator rod 272 is slidable relative to the distal wall of the flange cavity 271. The cam
12 housing 270 is connected at its distal end to the proximal end of the central shaft
13 portion 273 of the actuator rod 272. The cam housing 270 is positioned relative to the
14 barrel cam 268 so that when the magnet 291 rotates, the distal surface 277 of the
15 barrel cam 268 slidably engages the proximal surface of the follower 275 causing the
16 actuator rod 272, which is connected to the cam housing 270, to move axially.

17 The interior of the second casing 289 including the proximal cavity 226 and the
18 flange cavity 271 is filled with a fluid 295. The distal end of the interior of the second
19 casing 289 is sealed by an actuator rod boot 281.

20

21 *Operation:* The urethral device 210 is positioned in the urethra 204 using any
22 of the techniques described above in connection with the first embodiment. Figure 6
23 shows the urethral device 210 after it has been positioned in the urethra. In Figures 7
24 and 8, the urethral device 210 is in the closed position. As in the first embodiment,
25 urine is prevented from entering the urethral device 210 by the sealing of the inner
26 surface of the annular ring 238 to the angular flange 240.

27 To place the urethral device 210 in the open mode, an external actuation
28 magnet 326 is positioned close to the urethral device 210, as shown in Figure 9. In a
29 present embodiment, the external magnet 326 is positioned within approximately five
30 inches of urethral device 210 and approximately perpendicular to the axis 217. The
31 internal magnet 291 of the urethral device 210 rotates because its south-poled surface

1 296 is magnetically attracted and drawn towards the north-poled surface 328 of the
2 external actuation magnet 326. The speed of rotation of the internal magnet 291 is
3 controlled by the viscosity of the fluid 295 in the sealed proximal cavity 226 and the
4 clearance between the magnet 291 and the internal surface 227 of the second casing
5 289. The control of the rotation of magnet 291 provides a time delay mechanism in
6 the device. The distal pin 266 of the internal magnet 291 is connected at its distal end
7 to the barrel cam 268 so that rotation of the internal magnet 291 results in similar
8 angular displacement of the barrel cam 268. The distal cam face 277 of the barrel cam
9 268 slidably engages the follower 275, causing the cam housing 270 to displace the
10 actuator rod 272 along the axis 217 in a distal direction. Because the distal ring 278 of
11 the actuator rod 272 is fixed to the annular ring 238, distal axial movement of the
12 actuator rod 272 causes the annular ring 238 to likewise move distally. Displacement
13 of the annular ring 238 results in the compression of the bellows spring 244 and the
14 resultant shortening of the flexible bellows valve 242. This causes the separation of the
15 annular ring 238 from the angular flange 240, exposing the opening 239 in the
16 proximal end of the annular ring 238. Urine from the bladder is allowed to pass
17 through the drainage ports 216 and the opening 239 and then enter the passageway
18 243 located inside the annular ring 238. Flow of urine continues through the distal
19 fluid passageway 221 located inside the main portion 287 and out from the distal
20 opening 219 in the distal end 215 of the device 210 with only minimal restriction.

21 After the bladder is substantially empty, the flow of urine subsides. After the
22 flow of urine subsides, the device can be closed to prevent unintentional urine drainage
23 until the individual is ready to empty his or her bladder again. The device is closed by
24 removing the external actuation magnet 326 beyond the required activation range of
25 five inches or less. This eliminates the force that is transmitted through the internal
26 magnet 291, the cam 268, the cam housing 270, and the actuator rod 272 and that
27 maintains the bellows spring 244 in compression. Without the opposing force created
28 by the external magnet, the biasing force of the bellows spring 244 moves the actuator
29 rod 272 and the attached annular ring 238 proximally. This causes the proximal lip
30 233 of the annular ring 238 to seal against the angular flange 240, preventing the entry
31 of urine into the flow passageway 243 in the device. The proximal movement of

1 actuator rod 272 likewise causes the cam housing 270 to rotate the barrel cam 268
2 back to its initial position.

3

4 Materials: Except as noted below, the components of the second embodiment
5 are the same as or similar to the corresponding components in the first embodiment.

6 The angular flange 240 acts as a sealing surface to the annular ring 238. The
7 present material is a Teflon TFE and Acetal (Delrin AF) blend. The angular flange
8 240 has an approximate 15-degree distal taper that allows for a slight stretch of the
9 annular ring 238 as the annular ring 238 is pushed in to the angular flange 240 by the
10 bellows spring 244. The proximal portion of the angular flange 240 is a stepped,
11 cylindrical surface to interface with the bellows valve 242 and the bellows spring 244.
12 The outer diameter of the angular flange is approximately 5.3 mm (.210 inches) and
13 3.8 mm (.149 inches). The internal follower is sized and shaped to cooperate with the
14 helix of barrel cam 268.

15 The fluid 295 is preferably a medical grade glycerin with an ambient viscosity
16 of approximately 800 centi-poise at 70 degrees Fahrenheit. The fluid 295 is retained
17 within the proximal cavity 226 and the flange cavity 271 by an actuator rod boot 281,
18 which is easily deformed to accommodate the axial travel of the actuator rod 272.
19 Deformation of the actuator rod boot 281 allows for the necessary conservation of
20 volume required within a closed, fluid-filled system.

21 The flexible bellows valve 242 is constructed from a bellows spring 244 within
22 a layer formed by a thin polypropylene sleeve or layer 245. In one embodiment, the
23 bellows spring 244 is formed from 302 stainless steel wire. The spring constant of the
24 bellows spring 244 is approximately 4.5 N/m (.026 lbf/in) using an approximately .15
25 mm (.006 inches) wire wound with 6 active coils and 2 dead coils. The sleeve 245 is
26 formed using a polypropylene film approximately .013 mm (.0005 inches) thick.
27 Alternatively, the bellows valve 242 may be constructed from Shore A 30 durometer
28 medical grade silicone rubber (i.e. NuSil MED 4-4220). In this construction, the
29 bellows valve 242 provides a sealed interface between the angular flange 240 and the
30 tubing of the main portion 287. The bellows valve 242 is constructed with
31 approximately a .010 inch wall. The inner diameter is approximately 5.5 mm

1 (.216 inches), and the outer diameter is approximately 6.8 mm (.266 inches) with
2 approximately a 45-degree bellows wall angle. This construction provides
3 approximately 2.5 mm (.100 inches) axial displacement.

4 The proximal pin 262 is formed from nonmagnetic, 304 stainless steel wire,
5 approximately .020 inches in diameter.

6 Both the proximal journal 264 and distal journal 269 are cylindrical
7 components made from a Teflon TFE and Acetal (Delrin AF) blend. The proximal
8 journal 264 is press fit into the proximal wall of the second casing 289.

9 The distal pin 266 is formed from a nonmagnetic, 304 stainless steel wire,
10 approximately .020 inches in diameter. Its length is sufficient to engage the barrel cam
11 268 in order to transmit rotation of the internal magnet 291 to the barrel cam.

12 The barrel cam 268 is a cylindrical component with an external helix. The
13 external helix acts as a guide rail upon which the follower 275 slides. The barrel cam is
14 constructed from a Teflon TFE and Acetal (Delrin AF) blend. The barrel cam is press
15 fit onto the distal end of distal pin 266.

16 The internal magnet 291 is a Neodymium 45 ceramic material purchased from
17 PERMAG, a division of Dexter Magnetic Materials, as part number PN45C0140B,
18 magnetized through the diameter. The internal magnet 291 is cylindrical with an
19 outside diameter of approximately .140 inches by approximately .500 inches long and
20 may have two cylindrical recesses to receive the distal and proximal pins 262 and 266.

21 The external actuation magnet 326 is a Neodymium disk magnet, Part No.
22 ND030N-27, from The Magnet Source™.

23

24 Advantages: The second embodiment includes many of the same advantages
25 as the first embodiment. Like the first embodiment, the magnetically actuated
26 embodiment has its actuation components located outside the urine fluid flow path.
27 This provides the advantage that the dimensions of the urine fluid flow passageway can
28 be relatively large thereby providing for a correspondingly high flow rate and relatively
29 complete voiding of the bladder. This is advantageous for reducing discomfort and the
30 risk of infection.

31 One advantage provided by the magnetically actuated embodiment is that its

1 operation is controlled by the external magnet. Therefore, the second embodiment
2 would be useful for those individuals who might be unable to exert the necessary
3 muscular activity to operate the first embodiment. With the second embodiment, the
4 external magnet is used to positively activate the device to effect voiding of the
5 bladder. Because of viscous shear damping effects created by the magnet 291 rotating
6 in the fluid 295, the external magnet 326 is positioned in close proximity to the
7 indwelling device for a preset duration of time, e.g. 3-5 seconds or more, to cause the
8 device to open to let urine to flow through it. This avoids unintentional activation
9 which might be caused by accidentally passing the magnet close to the device or by
10 short, transient pressure peaks which might result from laughing, coughing, exercising,
11 etc.

12 Even though the magnetically actuated embodiment requires the sustained
13 application of the external magnetic field for activation, it also provides an over-
14 pressure fail-safe feature. As mentioned above in connection with the first
15 embodiment, the bladder pressure acting upon the proximally facing surface area of the
16 proximal lip of the annular ring is transformed into a distally directed force applied to
17 the annular ring. For this reason, the proximally facing surface area of the proximal lip
18 of the annular ring is made relatively small in area so that the resultant distally directed
19 force applied to the annular ring is likewise relatively small. Under normal operating
20 conditions, this distally directed force is insufficient to overcome the proximal biasing
21 force of the bellows spring which maintains the fluid seal between the annular ring and
22 the angular flange. However, if the bladder pressure becomes unusually high (for
23 example, when the individual is unconscious and unable to activate the device), the
24 distally directed force resulting from the application of the bladder pressure upon the
25 proximally directed surface area of the annular ring becomes sufficient to overcome the
26 biasing force of the bellows spring and causes compression of the bellows. Once the
27 bladder pressure is sufficient to compress the bellows spring, the device is opened and
28 urine can be voided from the bladder. Thus, the second embodiment provides this
29 automatic fail-safe feature to reduce the risk that the individual might be unable to
30 activate the device to empty his or her bladder.

31

1 III. THIRD EMBODIMENT.

2 A third embodiment of an indwelling urethral device 410 used to control urine
3 flow in an individual is shown in Figures 10 and 11. The components in the third
4 embodiment are similar or identical to those in the first embodiment, except as noted
5 below. Like the first embodiment, the embodiment shown in Figures 10 and 11 is
6 hydraulically actuated. The embodiment in Figures 10 and 11 includes a different kind
7 of biasing arrangement compared to the embodiment in Figures 1-5. In the
8 embodiment in Figures 10 and 11, the force threshold which is required to be
9 overcome to open the bellows valve is substantially non-linear. This non-linear force
10 threshold includes a relatively high force along an initial displacement of the bellows
11 valve and a relatively low force along the remainder of the displacement. The initial
12 displacement is relatively small compared to the remainder of the displacement. For
13 example, if the initial displacement is .004 inches (.1 mm), the remainder of the
14 displacement is approximately .096 inches (2.4 mm). This non-linear force threshold,
15 particularly when combined with damping of the actuator, provides a urethral device
16 with favorable operating characteristics.

17 The third embodiment 410 includes a second casing 489 located at a proximal
18 portion 412 of the body 420. The second casing 489 includes actuation ports 418
19 (shown in Figure 10) which permit fluid and/or fluid pressure to pass from outside the
20 second casing 489 to the interior 461 thereof. A sealed proximal fluid reservoir 460
21 and a sealed distal fluid reservoir 462 are located inside the second casing 489. The
22 proximal and distal fluid reservoirs 460 and 462 are filled with a fluid 458. A proximal
23 membrane 452 is located inside the second casing and forms at least a part of the wall
24 which defines the proximal fluid reservoir 460. The proximal membrane 452 is located
25 in the interior 461 of the second casing 489 so that it is exposed to the fluid pressure in
26 the bladder through the actuator ports 418. A distal membrane 468 is located inside
27 the second casing and forms at least a part of the wall which defines the distal fluid
28 reservoir 462.

29 The proximal and distal reservoirs 460 and 462 communicate with each other
30 through an opening 466 located in a journal sleeve 464. A plunger 465 is located in
31 the journal sleeve 464. The plunger 465 has a length such that a proximal end of the

1 plunger 465 is located in the proximal reservoir 460 and a distal end of the plunger 465
2 is located in the distal reservoir 462. The opening 466 through the journal sleeve 464
3 has a size relative to the plunger 465 that permits the plunger 465 to move freely
4 proximally and distally relative to the journal sleeve 464. Further, the opening 466
5 through the journal sleeve 464 is sized with respect to the size of the plunger 465 in
6 order to provide a restricted fluid path along the outside of the plunger 465 through
7 the opening 466 between the proximal and distal reservoirs 460 and 462 by which the
8 fluid 458 can pass between the reservoirs.

9 A distal end of the plunger 465 connects to a proximal end of a central shaft
10 portion 473 of an actuator rod 472. The central shaft portion 473 of the actuator rod
11 472 extends from the distal end of the plunger 465 through the distal reservoir 462,
12 through the distal membrane 468, and through a bore 447 located in a plug 441. The
13 distal end of the central shaft portion 473 of the actuator rod 472 connects to a distal
14 ring 478 of the actuator rod 472. The distal ring 478 connects to the inside of an
15 ultrasoft annular ring 438 located at a proximal end of a bellows valve 442. Located at
16 the proximal end of the annular ring 438 is a soft flexible proximal lip 433.

17 Located inside the second casing 489 is a latching mechanism. The latching
18 mechanism provides for a non-linear force which is required to be overcome in order
19 to open the urethral device to permit fluid to flow from the bladder through the device.
20 In the embodiment of Figures 10 and 11, the latching mechanism comprises a latch
21 spring 456. The latch spring 456 is located in the distal reservoir 462. The latch
22 spring 456 is comprised of an arm 455 connected at one end to the journal sleeve 464.
23 In the embodiment shown, the arm 455 is connected at its proximal end to the outer
24 circumference of the journal sleeve 464. The other end of the arm 455 is unattached or
25 otherwise formed to allow limited movement relative to the casing wall and/or the
26 plunger 465. The arm 455 is formed of a resilient, shape memory material. The arm
27 455 may be formed with a bowed or leaf shape. The distal end of the arm 455 may be
28 formed have a small rim. When the plunger 465 is in its most proximal position, the
29 distal end of the arm 455 engages the distal end of the plunger 465. If the distal end of
30 the arm 455 has a rim, the rim may extend over the distal edge of the plunger 465.
31 When the distal end of the arm 455 engages the distal edge of the plunger 465, the

1 plunger 465 is permitted to have no or only limited axial movement. This axial
2 movement, if permitted, is not of a magnitude sufficient to allow the attached ultrasoft
3 ring 438 (which is attached to the plunger 465 by way of the actuator rod 472) to
4 move away from the angular flange 440.

5 This embodiment may be operated in a manner similar to the first embodiment.
6 Fluid pressure in the bladder is transferred to the proximal membrane 452 in the
7 interior 461 of the second casing 489 through the actuation ports 418. Distal
8 movement of the plunger 465 is prevented by the distal end of the latch spring 456
9 which bears against the distal edge of the plunger 465. Distal movement of the plunger
10 465 is also opposed by a biasing force from the bellows spring 444 which is transferred
11 to the plunger 465 through the actuator rod 472. Of these, the opposing force
12 provided by the latch spring 456 is relatively larger than the force provided by the
13 bellows spring 444.

14 When fluid pressure in the bladder is sustained at a predetermined level for a
15 predetermined duration of time, the device opens to allow urine to flow from the
16 bladder into the drainage ports 416, through the device 410 out the body of the person
17 in whom the device is positioned. Sustained fluid pressure against the proximal
18 membrane 452 causes sufficient force to act on the plunger 465 to overcome the
19 biasing force of the latch spring 456. The latch spring 456 then resiliently bends away
20 from the distal edge of the plunger 465. When the distal end of the latch spring 456 is
21 no longer in engagement with the distal end of the plunger 465, it rides along the
22 exterior side of the plunger. Further distal movement of the plunger 465 is opposed by
23 the frictional force of the latch spring 456 bearing on the outside of the plunger 465,
24 the opposing biasing force of the bellows spring 444, and the frictional force associated
25 with moving the fluid 458 through the opening 466 from the proximal reservoir 460 to
26 the distal reservoir 462. The combination of these forces is less than the force
27 resulting from application of pressure from the bladder to the proximal membrane 452.
28 Therefore, the plunger 465 moves distally causing the annular ring 438 to move away
29 from the angular flange 440. Because the frictional force of the latch spring 456
30 against the outside of the plunger is substantially less than the biasing force that the
31 latch spring 456 applies against the distal edge of the plunger 465, a substantially non-

1 linear force opposing opening of the device results.

2 The device is closed in a manner similar to the first embodiment. When the
3 bladder is substantially empty, the flow through the device diminishes. The individual
4 relaxes so that relatively high bladder pressure is not sustained. This has the effect of
5 reducing the force applied to the proximal membrane 452 below the opposing force of
6 the bellows spring 444. This causes the plunger 465, which is connected to the
7 bellows, to move proximally and likewise causes the fluid 458 which had been in the
8 distal reservoir 462 to flow to the proximal reservoir 460 through the opening 466.
9 When the plunger 465 is moved to its proximal position, the latch spring 456 engages
10 the distal edge of the plunger 465 securing it in the proximal position. When the
11 plunger 465 is moved to its proximal position, the ring 438 is seated on the angular
12 flange 440 and the device is sealed to prevent flow of urine.

13 In this embodiment, the latching mechanism is described as being formed of a
14 latching spring that engages a plunger to provide a relatively high biasing force along
15 an initial distal displacement of the bellows and a relatively lower force along a
16 remaining portion of the distal displacement of the bellows. Other kinds of
17 mechanisms and means can be utilized to provide this kind of operating characteristic.
18 For example, various other kinds of springs, pins, latches, cams, threads arrangements
19 can be used to provide this kind of operating characteristic. Alternatively, this kind of
20 operating characteristic can also be provided by magnetic means.

21 This embodiment has the advantage that the latching mechanism provides a
22 well defined operating threshold to allow urine to be drained through the device. This
23 may make the device easier to adapt for different individuals and may make the device
24 easier to use for some individuals. A significant advantage provided by this
25 embodiment is that it has a relatively low activation threshold which makes the device
26 relatively easy to use. Another significant advantage of this embodiment is that despite
27 the relatively low activation threshold, it is relatively insensitive to brief, transient
28 pressure surges, which may occur due to exercise, coughing, etc. Still another
29 advantage of this embodiment is that once a bladder pressure of sufficient magnitude
30 and duration is applied, the device opens all the way relatively quickly due to the non-
31 linear characteristics provided by the latching mechanism. This allows for a relatively

1 large flow passage for urine which in turn provides for relatively quick and thorough
2 voiding. Still further, once the device is open, it stays fully open due to the damping
3 characteristics of the actuator thereby providing for relatively complete voiding of the
4 bladder.

5 In another alternative embodiment, the plunger shown in this embodiment may
6 be incorporated into a urethral device that does not have a latching mechanism, such as
7 the first embodiment disclosed above. In such an alternative embodiment, the device
8 would include a plunger that pushes an actuator rod to open the bellows valve, but
9 would not include a latch spring. Such an embodiment may optionally use a proximal
10 spring to assist in restoring the device to a closed position or alternatively the proximal
11 spring may be omitted and the biasing force of the bellows spring would be used to
12 close the device.

13

14 IV. FOURTH EMBODIMENT.

15 A fourth embodiment of an indwelling urethral device 610 used to control urine
16 flow in an individual is shown in Figure 12. The components in the fourth embodiment
17 are similar or identical to those in the second embodiment, except as noted below.
18 Like the second embodiment, this embodiment includes a magnetic actuator and like
19 the third embodiment, the embodiment of Figure 12 includes a latching mechanism that
20 provides for a non-linear force which is required to be overcome to open the device to
21 allow urine to be drained from the bladder.

22 The fourth embodiment 610 includes a second casing 689 located at a proximal
23 portion 612 of the body 620. Like the third embodiment, described above, the second
24 casing 689 includes actuation ports 618 which are located along the second casing 689
25 (similar to those shown in Figure 10). Located inside the second casing 689 is a sealed
26 cavity 626 having a proximal portion 660 and a distal portion 662. The sealed cavity
27 626 is filled with a fluid 658. A flexible proximal membrane 652 forms part of the wall
28 of the proximal portion 660 of the sealed cavity 626 and a flexible distal membrane 668
29 forms part of the wall of the distal portion 662 of the sealed cavity 626. The proximal
30 and distal portions 660 and 662 of the sealed cavity 626 are connected by a fluid
31 passageway 666 which is formed by a journal sleeve 664 fixed in the proximal cavity

1 626 of the second casing 689.

2 An internal magnet 691 is located in the proximal cavity 626 and mounted for
3 limited rotation about the axis 617. To provide for this rotation, the magnet 691 is
4 received in the passageway 666 of the cylindrical journal sleeve 664. A proximal end
5 of the magnet 691 is formed into a cam surface 677. This cam surface 677 bears
6 against a cam follower 675 formed as part of the proximal end of the journal sleeve
7 664. The cam surface 677 of the magnet 691 is positioned relative to the cam follower
8 675 of the journal sleeve 664 so that when the magnet 691 rotates, the cam surface
9 677 at the proximal end of the magnet 691 slidably engages the surface of the follower
10 675 causing the magnet 691 to move axially.

11 A central shaft portion 673 of an actuator rod 672 is connected to the distal
12 end of the magnet 691. The central shaft portion 673 of the actuator rod 672 extends
13 from distal end of the magnet 691 through the distal portion 662 of the cavity 626,
14 through the distal membrane 668, and through a bore 647 located in a plug 641. The
15 distal end of the central shaft portion 673 of the actuator rod 672 connects to a distal
16 ring 678 of the actuator rod 672. The distal ring 678 connects to the inside of an
17 ultrasoft annular ring 638 located at the proximal end of a bellows valve 642.

18 Located inside the second casing 689 is a latching mechanism. In the
19 embodiment of Figure 12, the latching mechanism comprises a latch spring 656 located
20 in the distal portion 662 of the sealed fluid cavity 626. The latch spring 656 may be
21 similar to the latch spring in the previously described embodiment. The latch spring
22 656 is comprised of an arm 655 connected at its proximal end to the inside wall of the
23 second casing 689. When the magnet 691 is in its most proximal position, the distal
24 end of the arm 655 engages the distal end of the magnet 691. When the magnet 691 is
25 in its proximal position, the ultrasoft ring 638 which is attached to the magnet 691 via
26 the actuator arm 672, is seated on the angular flange 640.

27 This embodiment may be operated in a manner similar to the second
28 (magnetically actuated) embodiment, described above. To place the urethral device
29 610 in the open mode, an external actuation magnet, similar to the device 326 shown
30 in Figure 9, is positioned within approximately five inches of urethral device 610 and
31 approximately perpendicular to the axis 617. The external magnet attracts the internal

1 magnet 691 tending to cause the internal magnet to rotate its north-south face toward
2 to the external magnet. However, since the end of the magnet 691 includes the cam
3 surface 677, rotation of the magnet 691 is accompanied by axial movement in a distal
4 direction which is opposed by the force of the latch spring 656. Once the latching
5 force of the latch spring 656 is overcome, continued rotation is opposed by the
6 substantially lower frictional force of the latch spring 656 riding on the outside surface
7 of the magnet 691. In addition, the rotation of the internal magnet 691 is damped by
8 the viscosity of the fluid 658 in the sealed proximal cavity 626 and the friction
9 associated with moving the fluid 658 from the proximal portion 660 to the distal
10 portion 662 of the cavity 626.

11 As the magnet is rotated, the proximal cam surface 677 of the magnet 691
12 slidably engages the follower 675, causing the magnet 691 and actuator rod 672 to
13 move along the axis 617 in a distal direction. Because the distal ring 678 of the
14 actuator rod 672 is fixed to the annular ring 638, distal axial movement of the actuator
15 rod 672 causes the annular ring 638 to move distally separating the annular ring 638
16 from the angular flange 640. Urine from the bladder is allowed to pass through the
17 drainage ports 616 and out from the distal opening in the distal end of the device.

18 After the bladder has been emptied, closing of the device may be accomplished
19 by removing the external magnet thereby allowing the biasing force of the bellows
20 spring 644 to move the annular ring 638 proximally to seal against the angular flange
21 640. When the magnet 691 is moved to its proximal position, the latch spring 656
22 engages the distal edge of the magnet 691 securing it in the proximal position.

23 This embodiment includes a fail-safe feature that allows for drainage of urine
24 from the bladder to avoid injury to the kidneys if the patient does not operate the
25 device with the magnet. If the patient does not operate the device when the bladder
26 becomes full, the pressure in the bladder rises. This bladder pressure is applied to the
27 proximal membrane 652 through the actuation ports 618 located in the second casing
28 689. When the bladder pressure reaches a predetermined magnitude for a sustained
29 period of time, sufficient fluid 658 is caused to flow from the proximal portion 660 of
30 the sealed cavity 626 to the distal portion 662 via the fluid passageway 666 formed in
31 the journal sleeve 664 past the magnet 691. This is sufficient to cause movement of

1 the annular ring 638 distally to open the device to allow urine to flow through the
2 device to relieve the high pressure condition in the bladder. The annular ring 638 may
3 open fully when activated in this manner by the high pressure condition applied to the
4 proximal membrane or alternatively, the annular ring 638 may open only slightly to
5 allow for a slow, weeping or seeping flow. A slow weeping or seeping flow may be
6 preferred since it is only necessary to drain enough urine to reduce the high pressure
7 condition and therefore it is not necessary to open the device completely which would
8 result in complete voiding of the bladder. The latch spring 655 may be used to provide
9 for this weeping flow operating characteristic. The latch spring 655 may continue to
10 engage the distal edge of the magnet 691 yet provide for slight movement of the
11 actuator rod 672 to allow the bellows valve 642 to open.

12

13 Like the third embodiment, this embodiment has the advantage that the latching
14 mechanism provides a well defined operating threshold to allow urine to be drained
15 from the device. This may make the device easier to adapt for different individuals and
16 may make the device easier to use for some individuals. Like the second embodiment,
17 the magnetic actuator provides for positive actuation which may be desired by some
18 individuals who do not have sufficient muscle control to use the hydraulically actuated
19 embodiments. A significant advantage provided by this embodiment is that it has a
20 relatively low activation threshold which permits the internal and external magnets to
21 be relatively small and convenient to use. Another significant advantage of this
22 embodiment is that despite the relatively low activation threshold, it is relatively
23 insensitive to brief, transient pressure surges, which may occur due to exercise,
24 coughing, etc. Still another advantage of this embodiment is that once a magnetic field
25 of sufficient strength and duration is applied, the device opens all the way relatively
26 quickly due to the non-linear characteristics provided by the latching mechanism. Still
27 further, once the device is open, it stays fully open due to the damping characteristics
28 associated with the magnetic actuator thereby providing for complete voiding of the
29 bladder.

30 Another important advantage provided by this embodiment is the fail-safe
31 feature. As described above, if the patient is unable to use the magnet to open the

1 device, high pressure conditions will cause the device to open, either fully or slightly.
2 to allow urine flow to relieve the high pressure condition. This feature is provided
3 automatically without the use of the magnet.
4

5 It is to be understood, however, the even though numerous characteristics and
6 advantages of the present invention have been set forth in the foregoing description,
7 together with details of the structure and function of present invention, the sequence or
8 order of the specific steps, or the actual compositions, environmental conditions, and
9 the like experienced or sensed may vary somewhat. Furthermore, it will be appreciated
10 that this disclosure is illustrative only and that changes may be made in detail,
11 especially in matters of shape, size, arrangement of parts, or sequence of elements of
12 the various aspects of the invention within the principles of the invention to the full
13 extent indicated by the broad general meaning of the terms in which the appended
14 claims are expressed.

1 WE CLAIM:

2 1. An apparatus for placement in a urethra of an individual for control of
3 urine flow comprising:

4 a tubular body sized for placement in the urethra, said tubular body having a
5 proximal portion adapted for placement in the bladder of the individual, a distal portion
6 opposite from said proximal portion, said tubular body having a lumen extending from
7 a distal opening in said distal portion to a proximal opening in said proximal portion;
8 and

9 a flexible bellows valve extendible between a bellows first position in which
10 said flexible bellows valve closes said proximal opening and a bellows second position
11 in which said flexible bellows valve exposes said proximal opening thereby permitting
12 urine to flow from the bladder through the lumen.

13

14 2. The invention of Claim 1 further comprising:

15 a magnet located internally of said tubular body and movable between a magnet
16 first position and a magnet second position in response to an applied external magnetic
17 field, said magnet coupled to said flexible bellows and operable to move said flexible
18 bellows between at least one of said bellows positions.

19

20 3. The invention of Claim 2 wherein said magnet is damped so that
21 sustained application of said external magnet field is required to move said magnet
22 between said first magnet position and said second magnet position.

23

24 4. The invention of Claim 1 further comprising:

25 an actuator located at said proximal portion and movable between an actuator
26 first position and an actuator second position in response to fluid pressure inside the
27 bladder said actuator coupled to said flexible bellows and operable to move said
28 flexible bellows between at least one of said bellows positions.

29

1 5. The invention of Claim 4 wherein said actuator is damped so that
2 transient pressure peaks of short duration in the bladder are ineffective to move said
3 actuator between said actuator first position and said actuator second position.

4
5 6. The invention of Claim 1 further comprising:
6 a latching mechanism coupled to said bellows valve and operative to apply a
7 force opposing movement of said bellows valve from said second position to said first
8 position.

9
10 7. The invention of Claim 6 wherein said latching mechanism is operative
11 to apply a relatively higher force opposing movement of said bellows valve from said
12 second position to said first position when said bellows valve is at said second position
13 and a relatively lower force when said bellows valve is displaced from said second
14 position toward said first position.

15
16 8. The invention of Claim 6 wherein said latching mechanism comprises a
17 latch spring coupled to said bellows valve.

18
19 9. An apparatus for placement in a urethra of an individual for voluntary
20 control of urine flow comprising:
21 a tubular body sized for placement in the urethra, said tubular body having a
22 proximal portion adapted for placement in the bladder of the individual, a distal portion
23 opposite from said proximal portion, said tubular body having a lumen extending from
24 a distal opening in said distal portion to a proximal opening in said proximal portion;
25 and
26 an actuator coupled to a valve operable to open and close said proximal
27 opening, said actuator located in said proximal portion proximal of said proximal
28 opening.

29
30 10. The invention of Claim 9 wherein said valve further comprises:
31 a flexible bellows extendible between a bellows first position in which said

1 flexible bellows closes said proximal opening and a bellows second position in which
2 said flexible bellows exposes said proximal opening thereby permitting urine to flow
3 from the bladder through the lumen.
4

5 11. The invention of Claim 9 wherein said actuator is damped so that
6 transient pressure peaks of short duration in the bladder are ineffective to cause said
7 actuator to open and close said valve.
8

9 12. The invention of Claim 9 wherein said actuator comprises:
10 a magnet located internally of said tubular body and movable between a magnet
11 first position and a magnet second position in response to an applied external magnetic
12 field.
13

14 13. The invention of Claim 9 wherein said actuator comprises:
15 a fluid pressure sensor responsive to fluid pressure in the bladder.
16

17 14. The invention of Claim 9 further comprising:
18 a latching mechanism coupled to said actuator and operative to apply a
19 relatively higher force opposing opening of said valve when said valve is in a closed
20 position and a relatively lower force opposing opening of said valve when said valve is
21 displaced from said closed second position.
22

23 15. An apparatus for placement in a urethra of an individual for control of
24 urine flow comprising:
25 a tubular body sized for placement in the urethra, said tubular body having a
26 proximal portion adapted for placement in the bladder of the individual, a distal portion
27 opposite from said proximal portion, said tubular body having a lumen extending from
28 a distal opening in said distal portion to a proximal opening in said proximal portion;
29 and
30 a valve operable to open and close said proximal opening; and

1 a damped actuator responsive to an actuation force applied thereupon, said
2 damped actuator coupled to said valve and operable to open said valve in response to
3 application of an actuation force for a predetermined duration and to maintain said
4 valve closed upon application of an actuation force for less than said predetermined
5 duration.

6

7 16. The invention of Claim 15 wherein said damped actuator further
8 comprises:

9 a magnet located internally of said tubular body and movable between a magnet
10 first position and a magnet second position in response to an applied external magnetic
11 field, said magnet coupled to said valve and operable to move said valve between at
12 least one of two valve positions.

13

14 17. The invention of Claim 16 wherein said magnet is located in a chamber
15 filled with a damping fluid.

16

17 18. The invention of Claim 15 wherein said damped actuator further
18 comprises:

19 a fluid sensor responsive to fluid pressure inside the bladder.

20

21 19. The invention of Claim 18 wherein said fluid sensor comprises:

22 a first movable surface exposed to said fluid pressure inside the bladder;

23 a second movable surface coupled to said valve;

24 at least one reservoir adjacent to at least one of said movable surfaces; and

25 damping fluid contained in said reservoir.

26

27 20. The invention of Claim 18 wherein said fluid sensor comprises:

28 a first reservoir having a first surface exposed to said fluid pressure inside the
29 bladder;

30 a second reservoir having a second surface coupled to said valve;

1 a restrictive fluid passageway connecting said first reservoir and said second
2 reservoir; and
3 a damping fluid contained in said first and said second reservoirs and movable
4 therebetween through said restrictive fluid passageway.

5
6 21. The invention of Claim 15 wherein said valve further comprises:
7 a flexible bellows extendible between a bellows first position in which said
8 flexible bellows closes said proximal opening and a bellows second position in which
9 said flexible bellows exposes said proximal opening thereby permitting urine to flow
10 from the bladder through the lumen.

11
12 22. The invention of Claim 15 further comprising:
13 a latching mechanism coupled to said damped actuator and operative to apply a
14 relatively higher force opposing opening of said valve when said valve is in a closed
15 position and a relatively lower force opposing opening of said valve when said valve is
16 displaced from said closed second position.

17
18 23. The invention of Claim 15 wherein said damped actuator requires a
19 sustained actuation force to be applied thereto for said predetermined duration to open
20 said valve.

21
22 24. An apparatus for placement in a urethra of an individual for control of
23 urine flow comprising:
24 a tubular body sized for placement in the urethra, said tubular body having a
25 proximal portion adapted for placement in the bladder of the individual, a distal portion
26 opposite from said proximal portion, said tubular body having a lumen extending from
27 a distal opening in said distal portion to a proximal opening in said proximal portion;
28 and

29 a valve operable to open and close said proximal opening; and
30 a damped actuator responsive to an actuation force applied thereupon, said
31 damped actuator coupled to said valve and operable to maintain said valve in an open

1 position in response to application of an actuation force and to maintain said valve in
2 said open position for a predetermined duration after cessation of said application of
3 said actuation force.

4

5 25. The invention of Claim 24 wherein said damped actuator further
6 comprises:

7 a magnet located internally of said tubular body and movable between a magnet
8 first position and a magnet second position in response to an applied external magnetic
9 field, said magnet coupled to said valve and operable to move said valve between at
10 least one of two valve positions.

11

12 26. The invention of Claim 25 wherein said magnet is located in a chamber
13 filled with a damping fluid.

14

15 27. The invention of Claim 24 wherein said damped actuator further
16 comprises:

17 a fluid sensor responsive to fluid pressure inside the bladder.

18

19 28. The invention of Claim 27 wherein said fluid sensor comprises:
20 a first movable surface exposed to said fluid pressure inside the bladder;
21 a second movable surface coupled to said valve;
22 at least one reservoir adjacent to at least one of said movable surfaces; and
23 damping fluid contained in said reservoir.

24

25 29. The invention of Claim 27 wherein said fluid sensor comprises:
26 a first reservoir having a first surface exposed to said fluid pressure inside the
27 bladder;
28 a second reservoir having a second surface coupled to said valve;
29 a restrictive fluid passageway connecting said first reservoir and said second
30 reservoir; and

1 a damping fluid contained in said first and said second reservoirs and movable
2 therebetween through said restrictive fluid passageway.

3

4 30. The invention of Claim 24 wherein said valve further comprises:

5 a flexible bellows extendible between a bellows first position in which said
6 flexible bellows closes said proximal opening and a bellows second position in which
7 said flexible bellows exposes said proximal opening thereby permitting urine to flow
8 from the bladder through the lumen.

9

10 31. The invention of Claim 24 further comprising:

11 a latching mechanism coupled to said damped actuator and operative to apply a
12 relatively higher force opposing opening of said valve when said valve is in a closed
13 position and a relatively lower force opposing opening of said valve when said valve is
14 displaced from said closed second position.

15

16 32. An apparatus for placement in a urethra of an individual for voluntary
17 control of urine flow comprising:

18 a tubular body sized for placement in the urethra, said tubular body having a
19 proximal portion adapted for placement in the bladder of the individual, a distal portion
20 opposite from said proximal portion, said tubular body having a lumen extending from
21 a distal opening in said distal portion to a proximal opening in said proximal portion,
22 wherein said proximal opening exposed to bladder when positioned in the urethra; and

23 a bellows coupled to said tubular body and having an end that is extendible
24 between a first position and a second position, said bellows end operable to close said
25 proximal opening in said first position and to expose said opening in said second
26 position; and

27 an actuator located at said proximal portion, said actuator including an
28 actuation surface coupled to said bellows end and responsive to an actuation force
29 applied thereto and a reservoir adjacent to said surface and containing a fluid that
30 damps transfer of movement between said actuation surface and said bellows.

31

1 33. The invention of Claim 32 wherein said actuation surface comprises an
2 internal magnet.

3
4 34. The invention of Claim 32 wherein said actuation surface comprises at
5 least one membrane responsive to ambient pressure in the bladder.

6
7 35. The invention of Claim 32 wherein said proximal portion of said body
8 comprises:

9 a distal casing containing said bellows, said distal casing having at least one
10 drainage port located therein to permit fluid access to said proximal opening from the
11 bladder.

12
13 36. The invention of Claim 35 wherein said proximal portion of said body
14 further comprises:

15 a proximal casing containing said actuator, said proximal casing located
16 proximal of said distal casing.

17
18 37. The invention of Claim 36 wherein said proximal casing includes at
19 least one actuation port providing for transfer of fluid pressure from the bladder to said
20 actuation surface.

21
22 38. The invention of Claim 36 wherein said proximal casing comprises a
23 sealed chamber in which is located said actuation surface and wherein said actuation
24 surface comprises a magnet.

25
26 39. The invention of Claim 32 further comprising:

27 a latching mechanism operatively coupled to apply a relatively higher force
28 opposing movement of said bellows end from said first position and a relatively lower
29 force opposing movement of said bellows end when said bellows end is displaced from
30 said closed first position.

31

1 40. A method of controlling urine flow from a bladder of an individual
2 comprising:
3 positioning a urethral device in the urethra so that a proximal portion of the
4 urethral device is located in fluid communication with the bladder;
5 maintaining a valve in a closed position to close a proximal opening into a
6 lumen that extends through the tubular device;
7 continuing to maintain said valve in said closed position upon application of a
8 force of at least a predetermined magnitude to an actuator located in said proximal
9 portion for less than a predetermined duration of time;
10 opening said valve upon application of a sustained force of at least said
11 predetermined magnitude to said actuator for at least said predetermined period of
12 time;
13 continuing to maintain said valve in an open position for a second
14 predetermined period of time until after cessation of said application of said sustained
15 force to said actuator; and
16 closing said valve after said second predetermined period of time.

17
18 41. The method of Claim 40 wherein the force is applied by a magnetic
19 field.

20
21 42. The method of Claim 40 wherein the force is applied by fluid pressure
22 in the bladder.

23
24 43. A method of controlling urine flow from a bladder of an individual with
25 a urethral device having a normal mode of operation and a fail-safe mode of operation,
26 comprising the steps of:
27 positioning the urethral device in the urethra of the individual so that a
28 proximal portion of the urethral device is located in fluid communication with the
29 bladder;
30 maintaining a valve in a closed position to close a proximal opening into a
31 lumen that extends through the urethral device;

1 in a normal mode of operation, continuing to maintain said valve in said closed
2 position upon application of a magnetic force of at least a predetermined magnitude to
3 an actuator located in said proximal portion for less than a predetermined duration of
4 time; and
5 opening said valve upon application of a sustained magnetic force of at least
6 said predetermined magnitude to said actuator for at least said predetermined period of
7 time; and
8 in a fail-safe mode of operation, opening said valve upon application of a force
9 resulting from a sustained fluid pressure in the bladder force for a second
10 predetermined duration of time.

11

12 44. An apparatus for placement in a urethra of an individual for voluntary
13 control of urine flow comprising:

14 a tubular body sized for placement in the urethra, said tubular body having a
15 proximal portion adapted for placement in the bladder of the individual, a distal portion
16 opposite from said proximal portion, said tubular body having a lumen extending from
17 a distal opening in said distal portion to a proximal opening in said proximal portion;

18 a valve operable to open and close said proximal opening; and

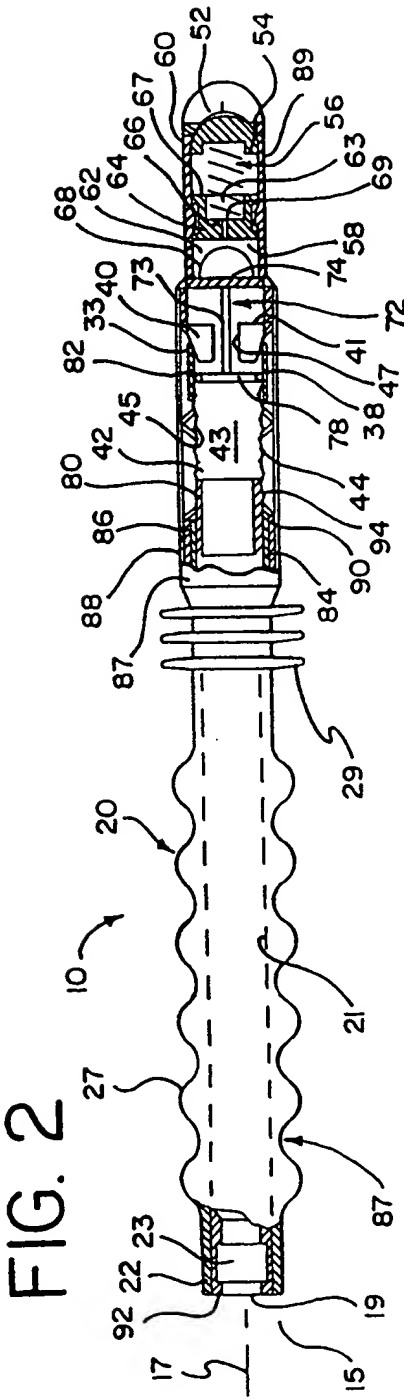
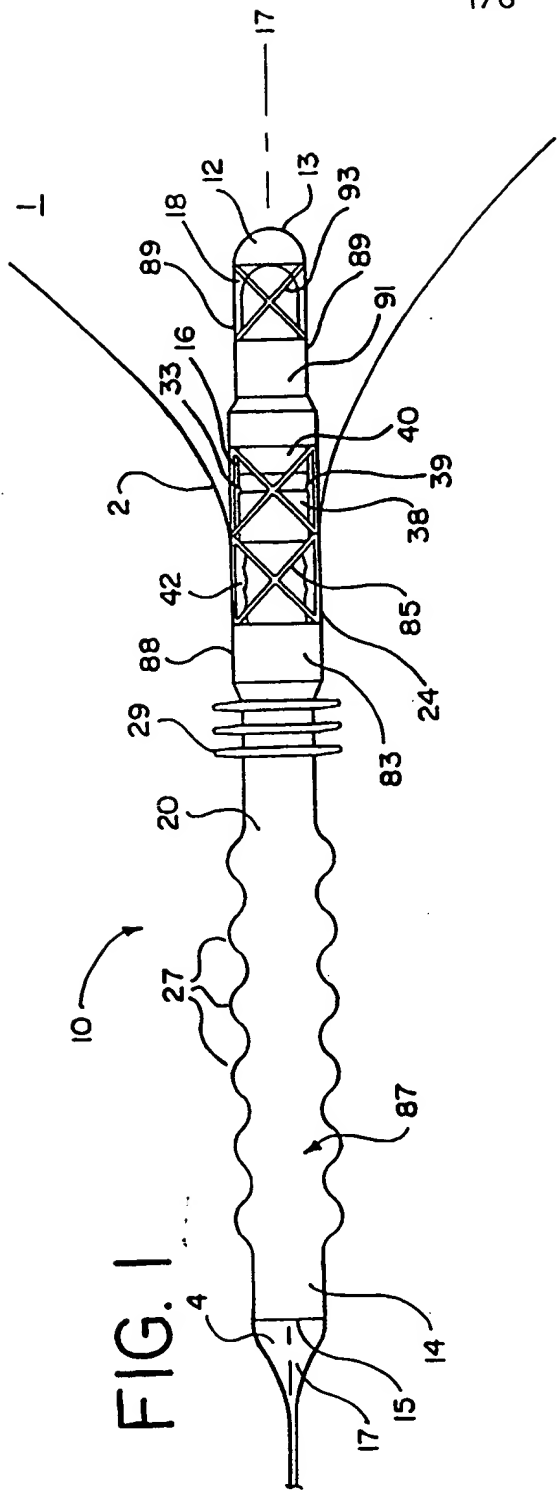
19 a latching mechanism coupled to said valve and operative to apply a relatively
20 higher force opposing opening of said valve when said valve is in a closed position and
21 a relatively lower force opposing opening of said valve when said valve is displaced
22 from said closed second position.

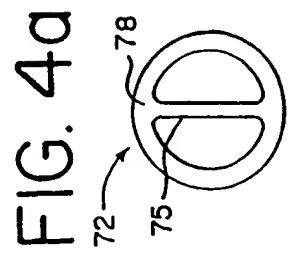
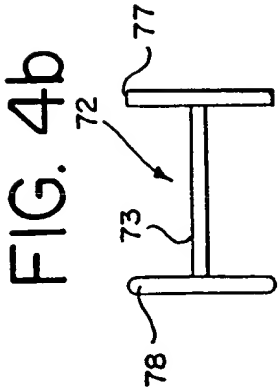
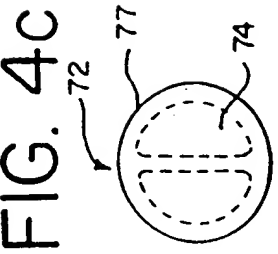
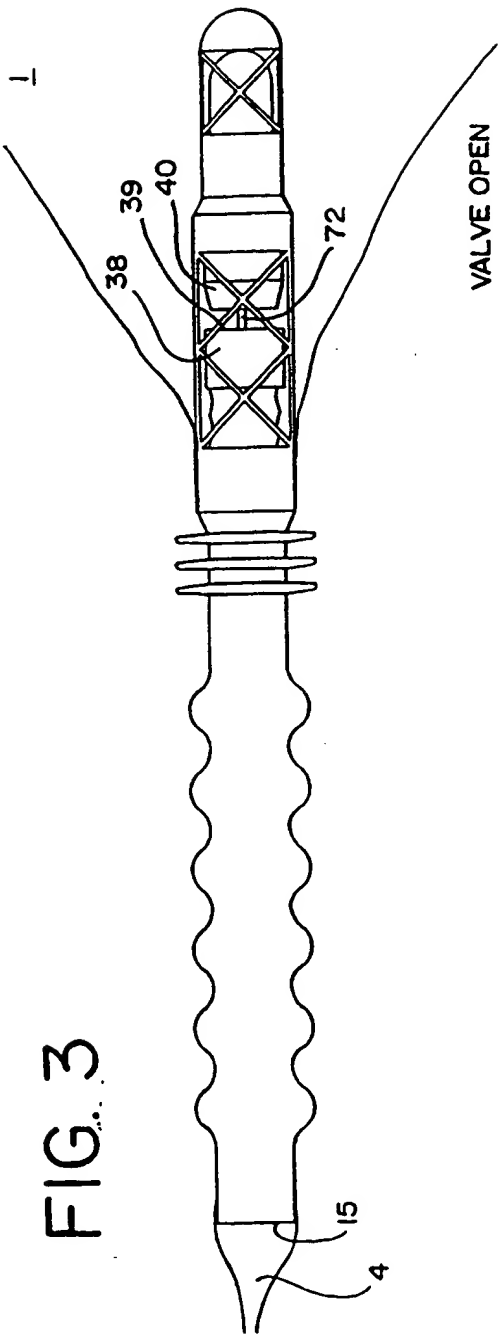
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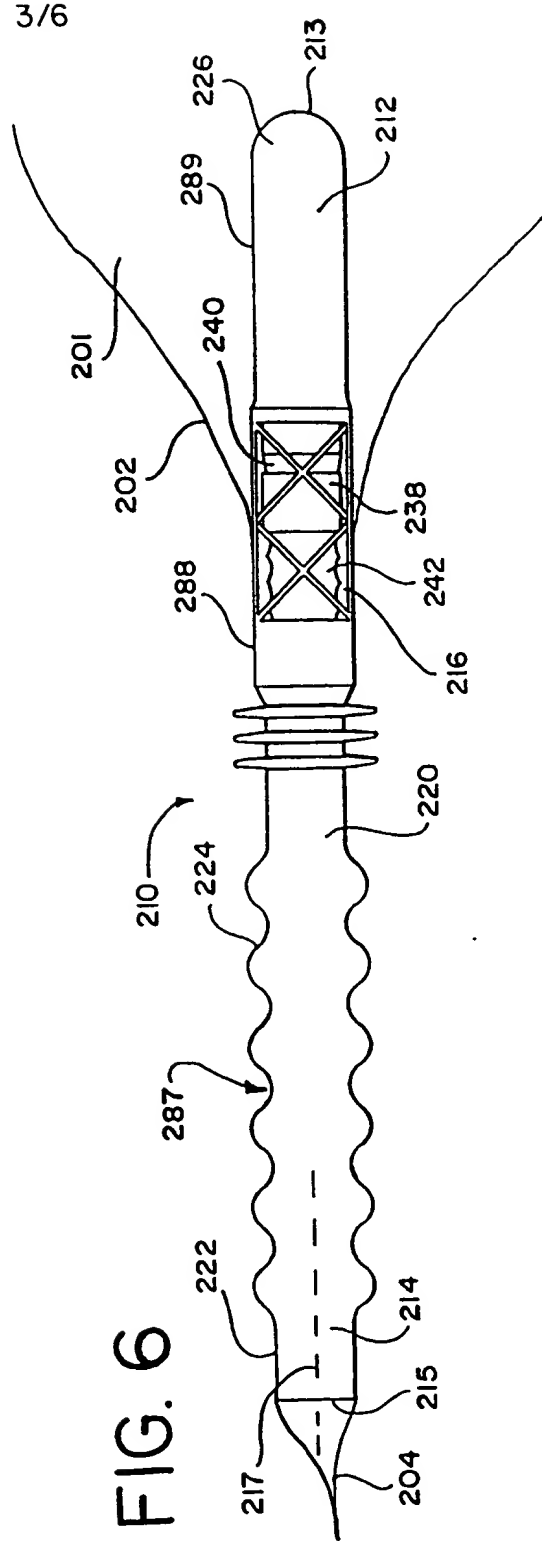
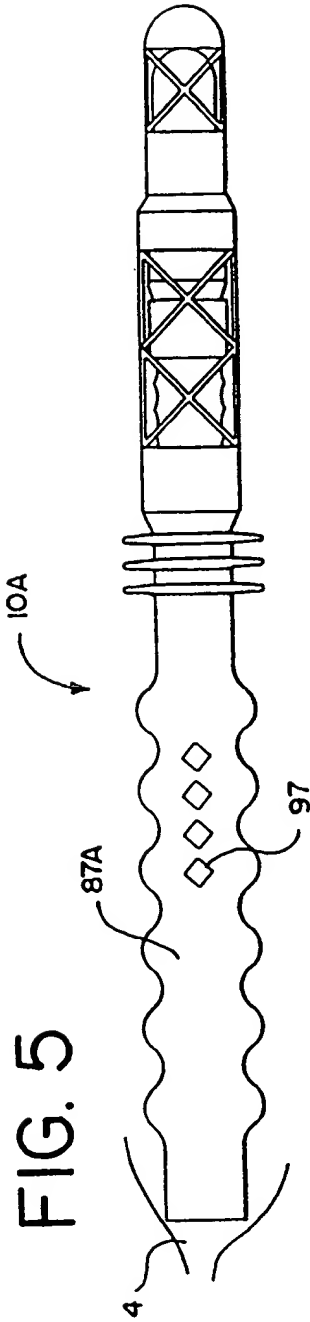
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26







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FIG. 7

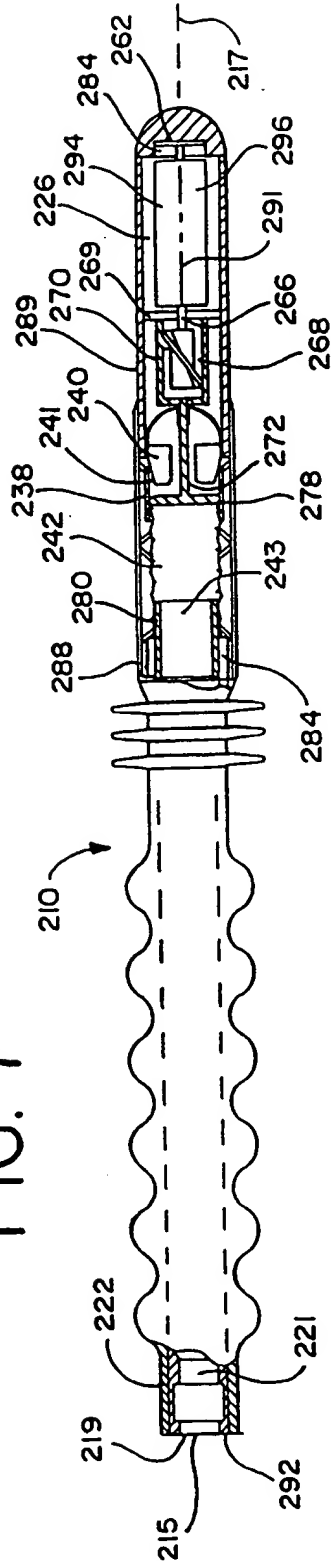
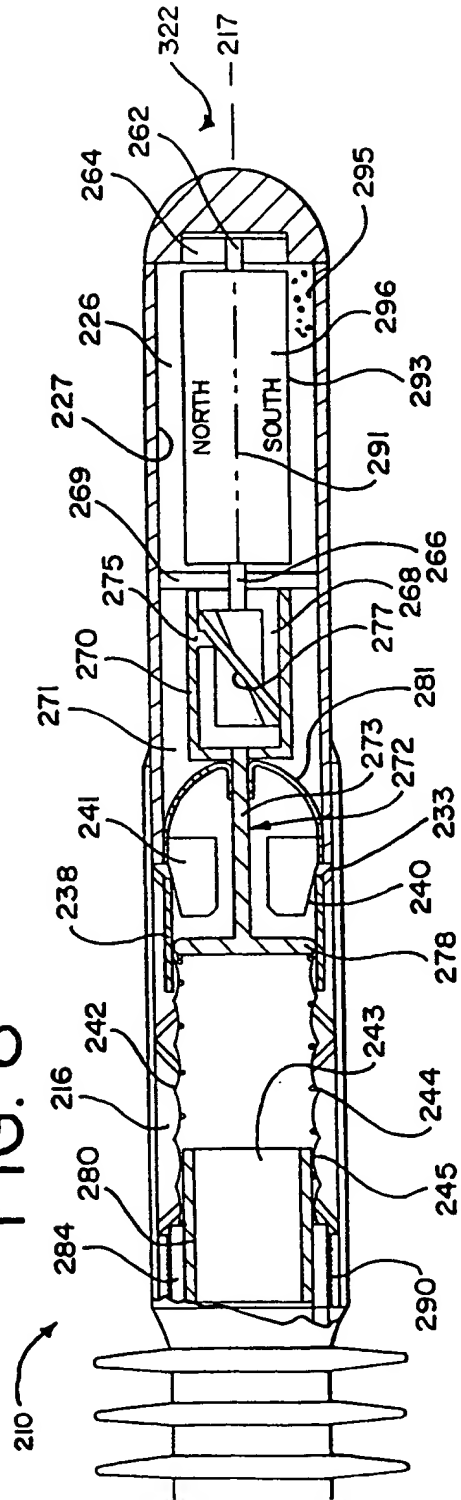


FIG. 8



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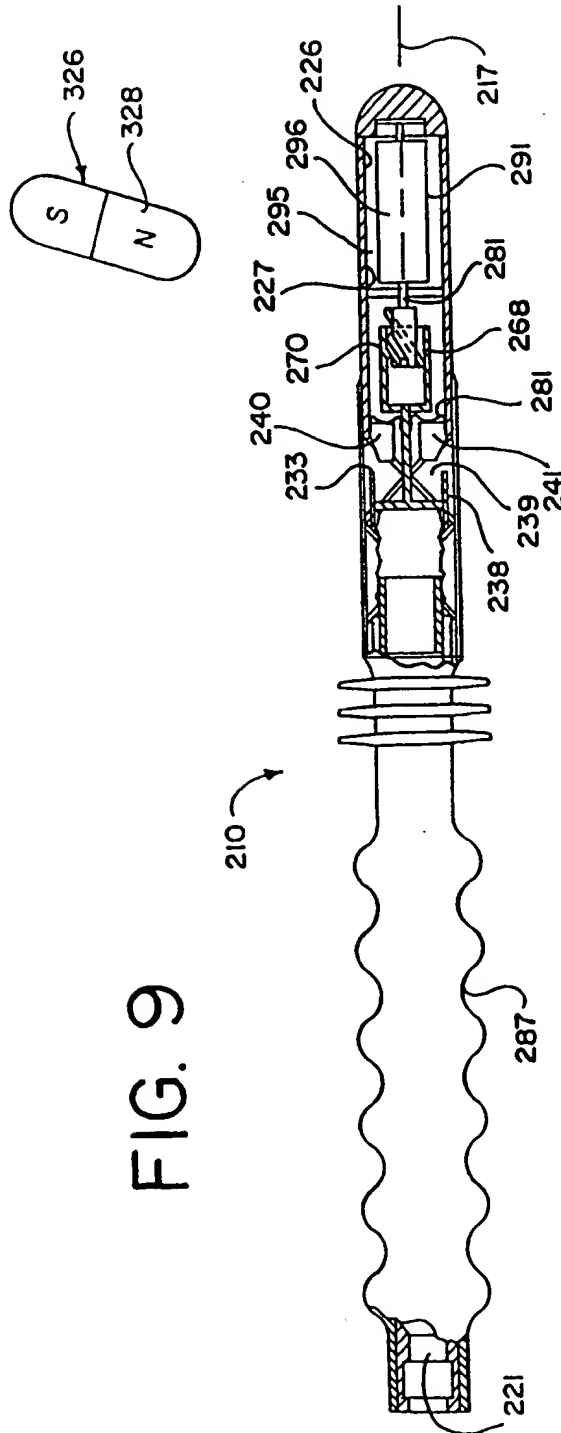


FIG. 9

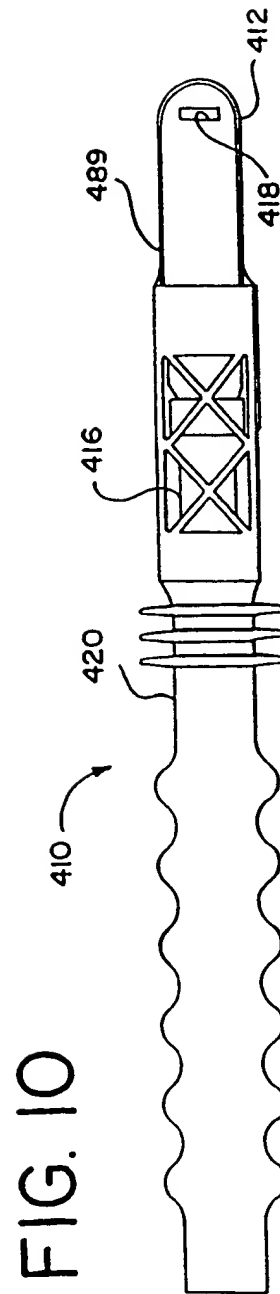


FIG. 10

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FIG. 11

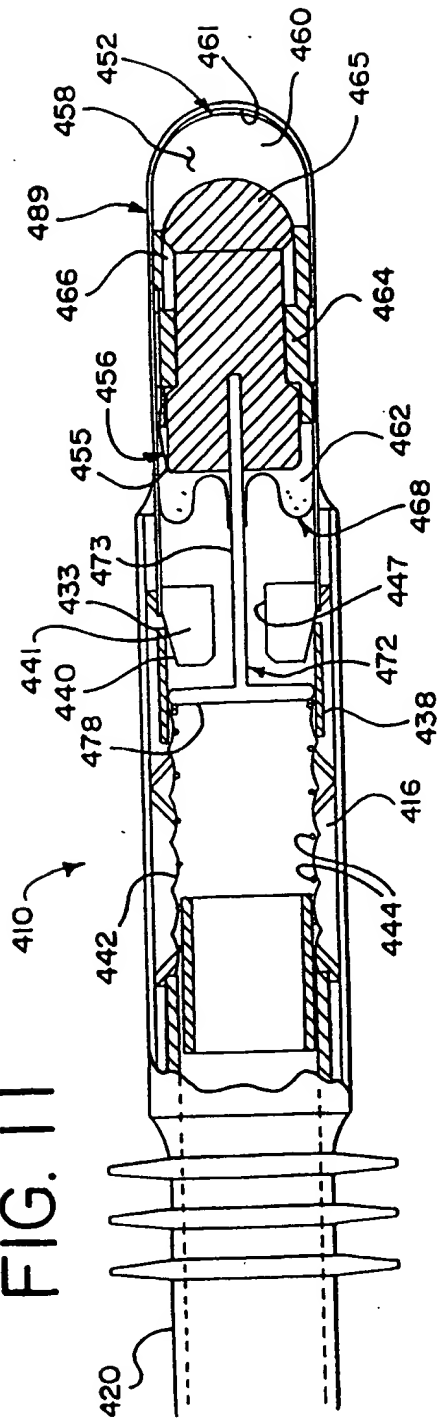
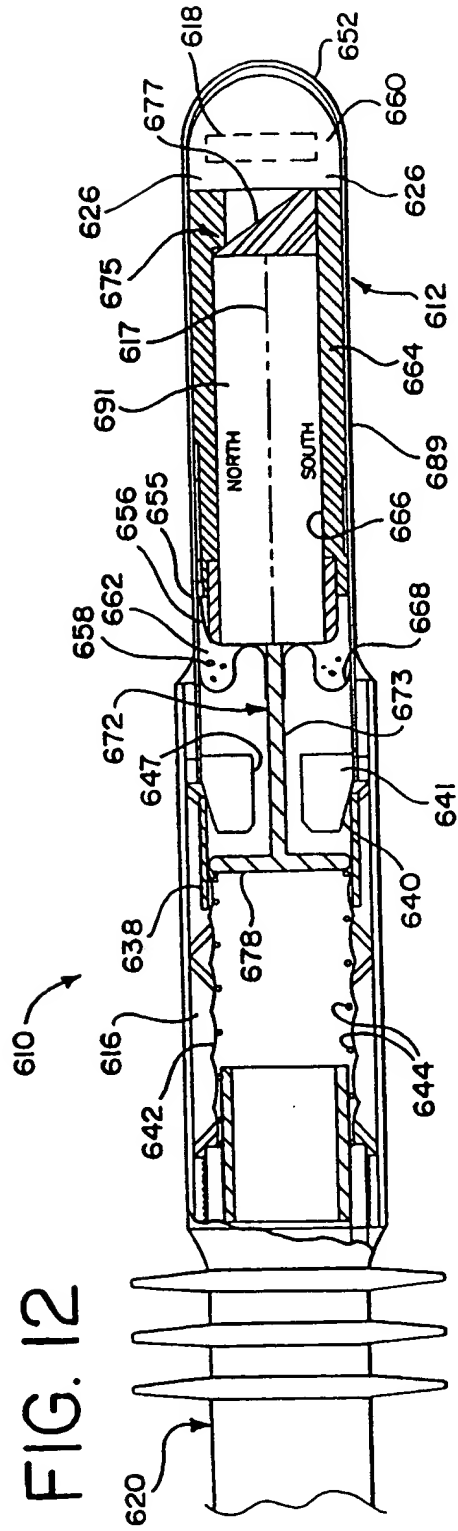


FIG. 12



INTERNATIONAL SEARCH REPORT

International application No.
PCT/US98/26509**A. CLASSIFICATION OF SUBJECT MATTER**

IPC(6) :A61F 2/00

US CL :600/29

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 128/DIG. 25: 600/29-31: 604/93, 96, 102

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 4,553,533 A (LEIGHTON) 19 November 1985, entire document.	1-44
Y	US 3,812,841 A (ISAACSON) 28 May 1974, entire document.	1-44
Y	US 5,476,434 A (KALB et al) 19 December 1995, col. 5 lines 13-44.	13, 18, 27

☐

Further documents are listed in the continuation of Box C.

☐

See patent family annex.

* Special categories of cited documents:	*T* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
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L document which may throw doubt on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	*Z* document member of the same patent family
O document referring to an oral disclosure, use, exhibition or other means	
P document published prior to the international filing date but later than the priority date claimed	

Date of the actual completion of the international search

04 MARCH 1999

Date of mailing of the international search report

30 MAR 1999

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